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VanDerWoude et al.

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(54) **PERSONAL PROTECTION SYSTEM INCLUDING A HELMET WITH A SENSOR**

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A42B 3/28 (2006.01)
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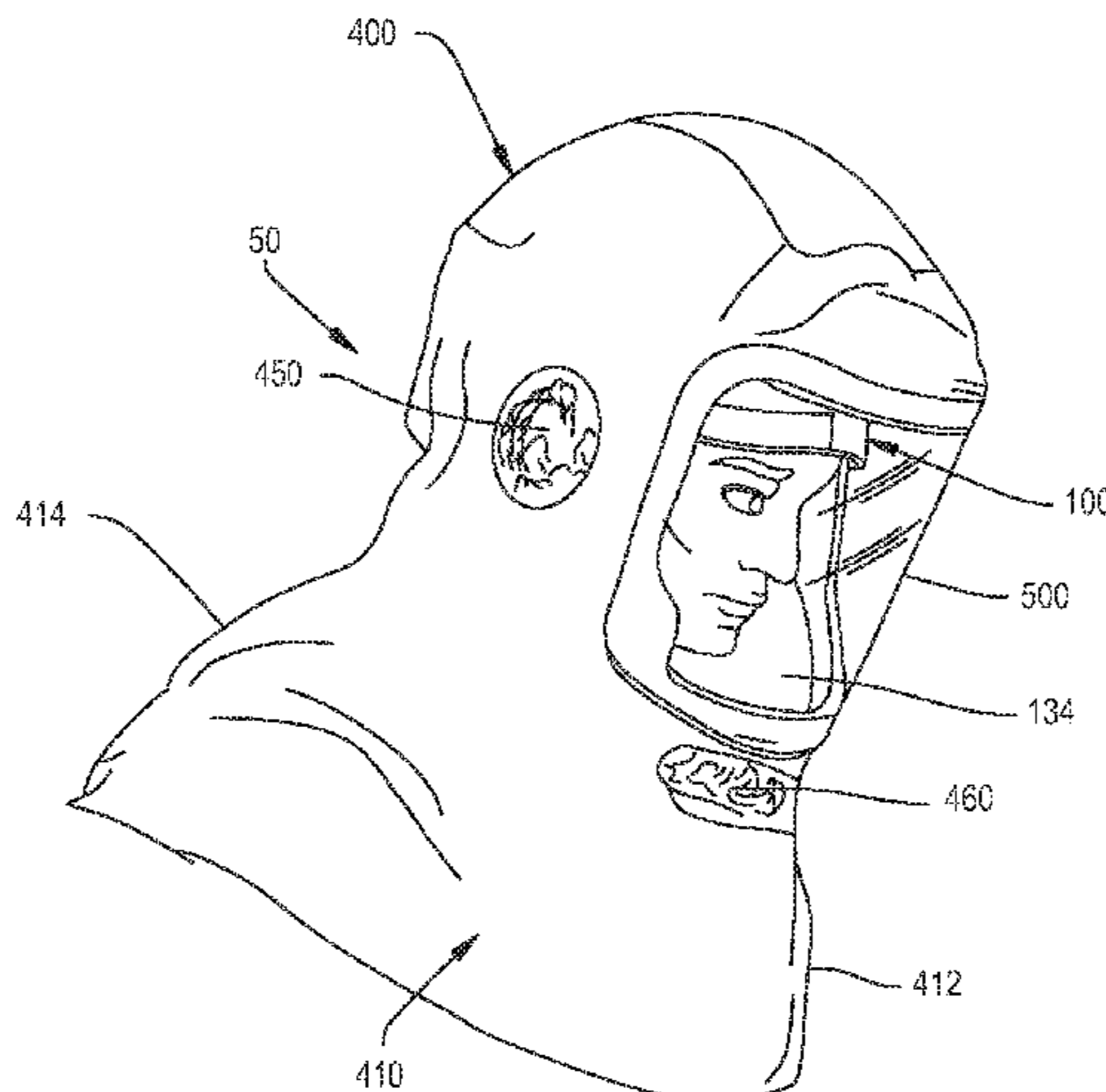
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(57) **ABSTRACT**

A personal protection system including a helmet worn on the head of a user and a hood removably coupled to the helmet. The helmet may comprise a ventilation assembly, a chin bar and a control circuit. The chin bar may comprise a mounting device and a hall effect sensor mounted adjacent the mounting device. The hall effect sensor may be in communication with the control circuit. The hood may comprise a transparent face shield and a mounting element configured to removably couple with the mounting device of the helmet. The control circuit may be configured to receive a signal from said hall effect sensor indicating the coupling of said mounting element of said hood with said mounting device of said helmet.

20 Claims, 20 Drawing Sheets



Related U.S. Application Data

- continuation of application No. PCT/US2014/025919, filed on Mar. 13, 2014.
- (60) Provisional application No. 61/783,234, filed on Mar. 14, 2013.
- (51) **Int. Cl.**
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A62B 7/00 (2006.01)
A62B 18/08 (2006.01)
- (52) **U.S. Cl.**
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- (58) **Field of Classification Search**
 CPC A42B 3/0406; A42B 3/20; A42B 3/225; A42B 3/28–288
- See application file for complete search history.

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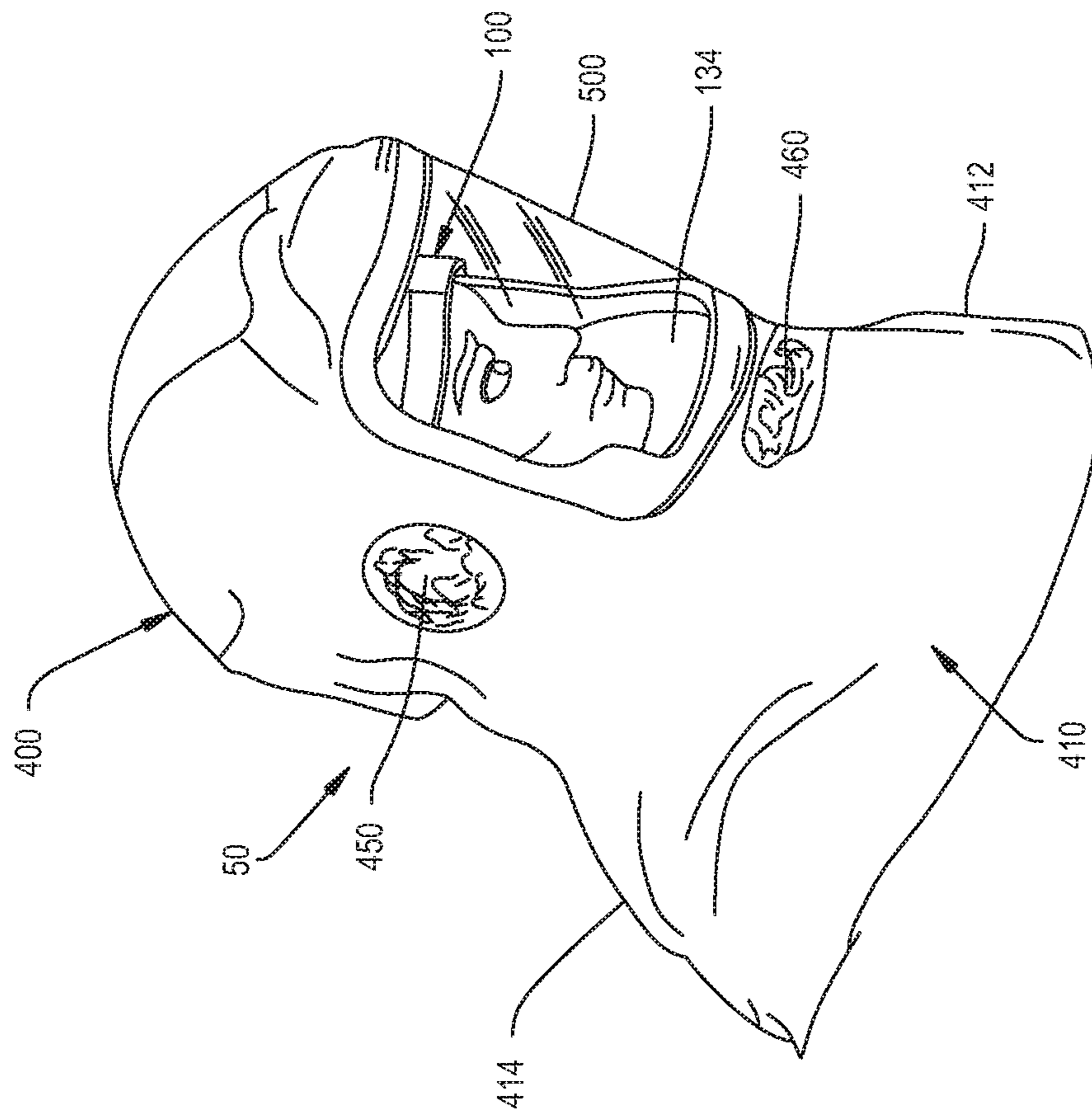


FIG. 1

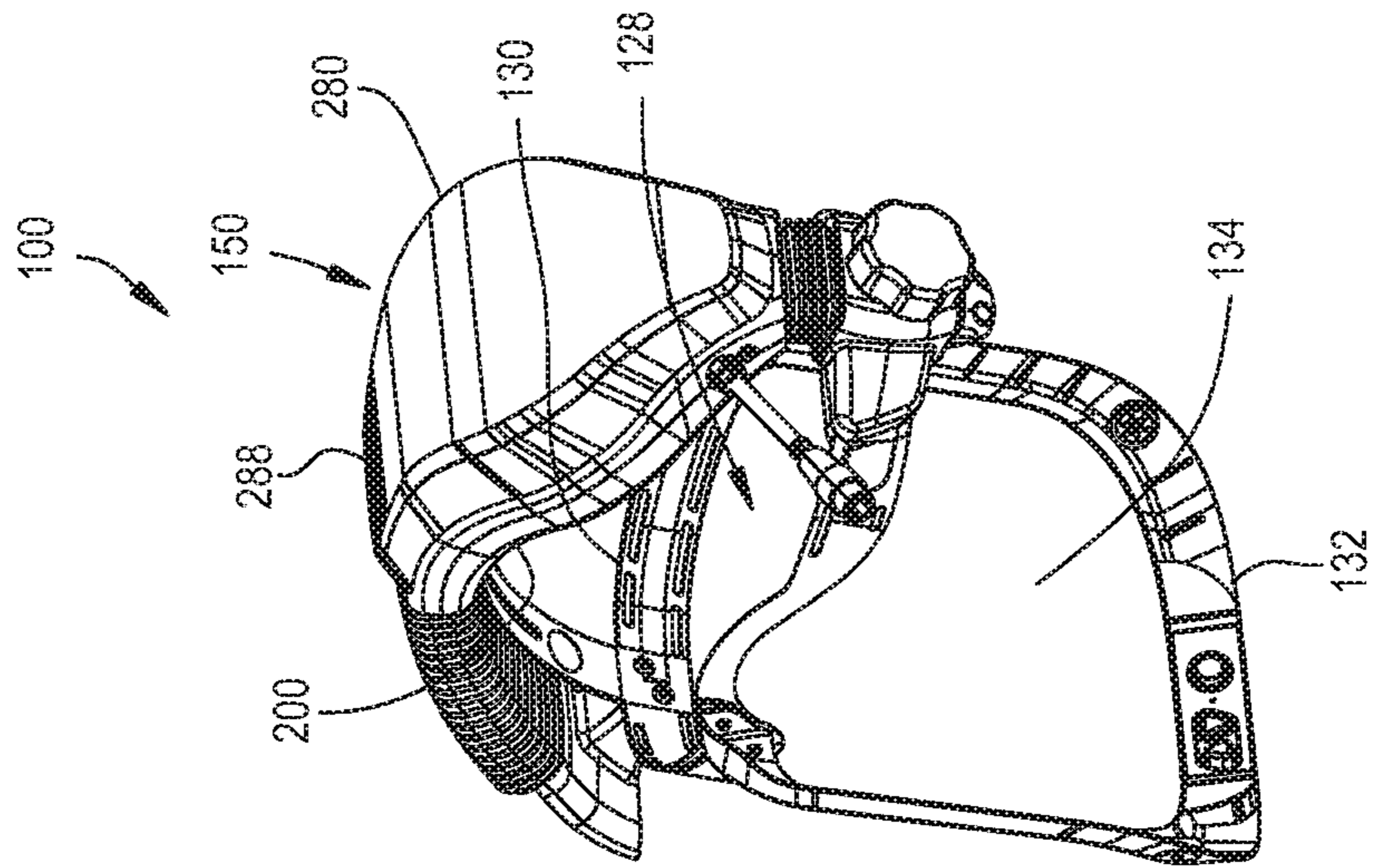


FIG. 3

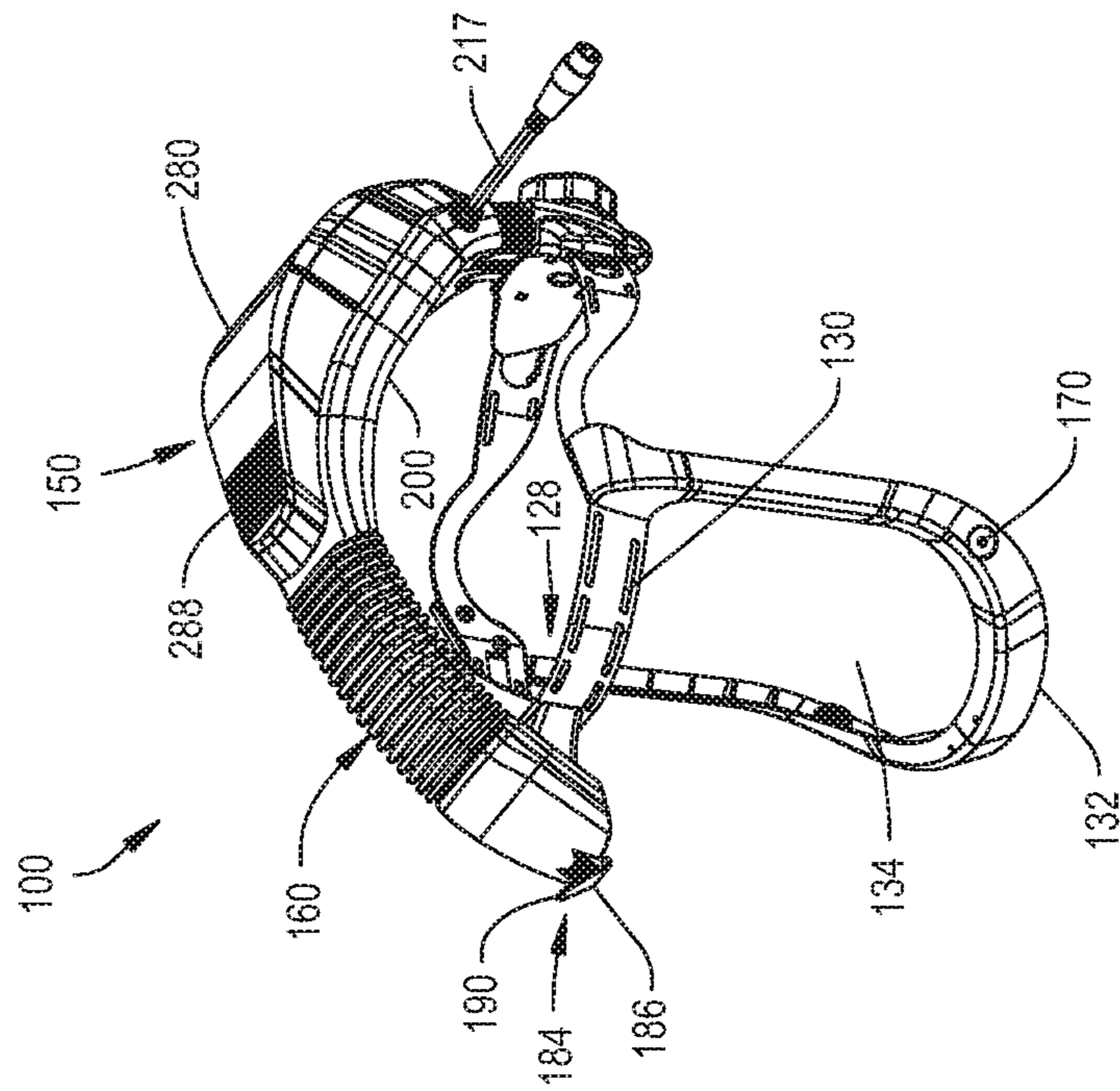
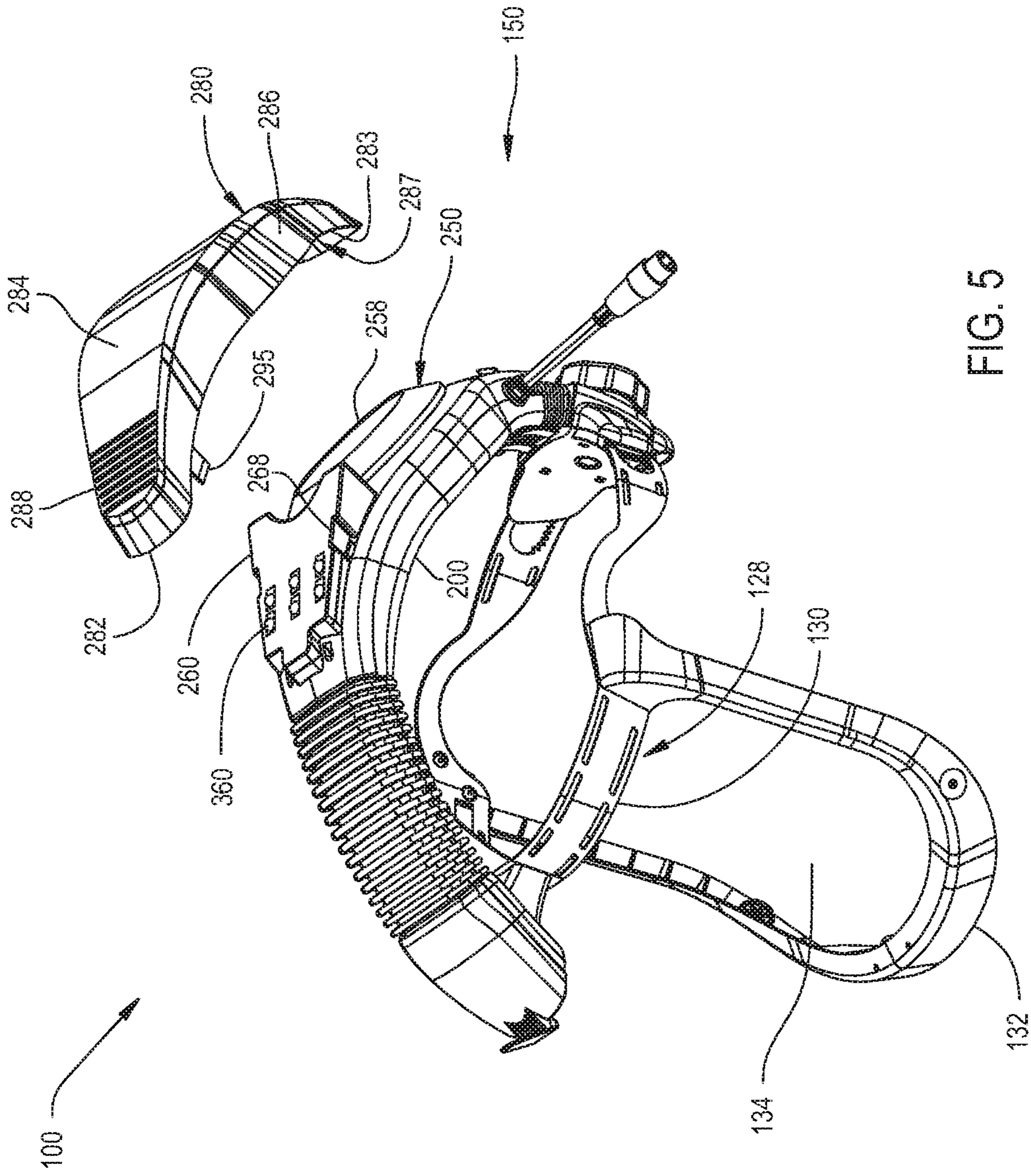
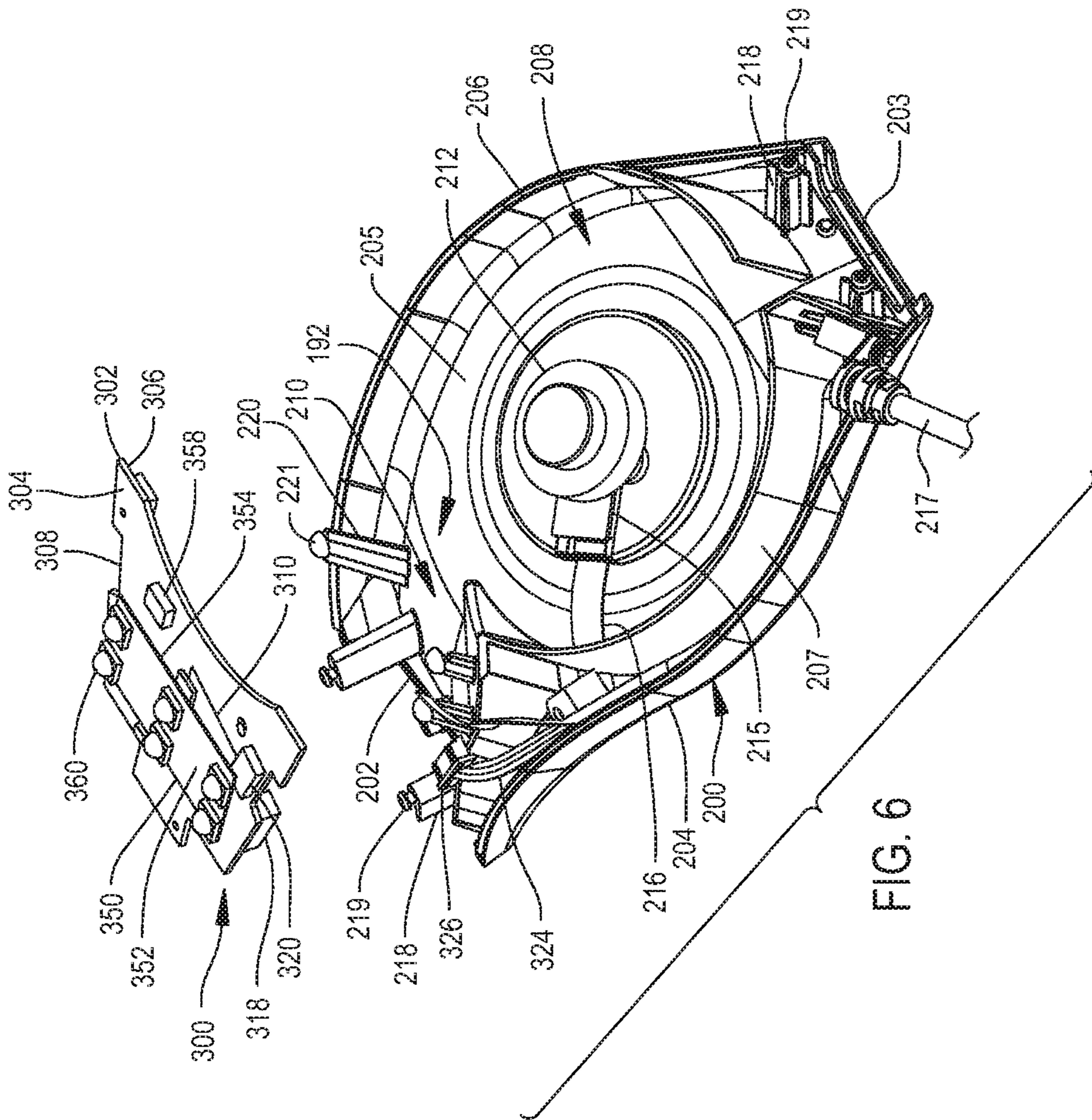


FIG. 2





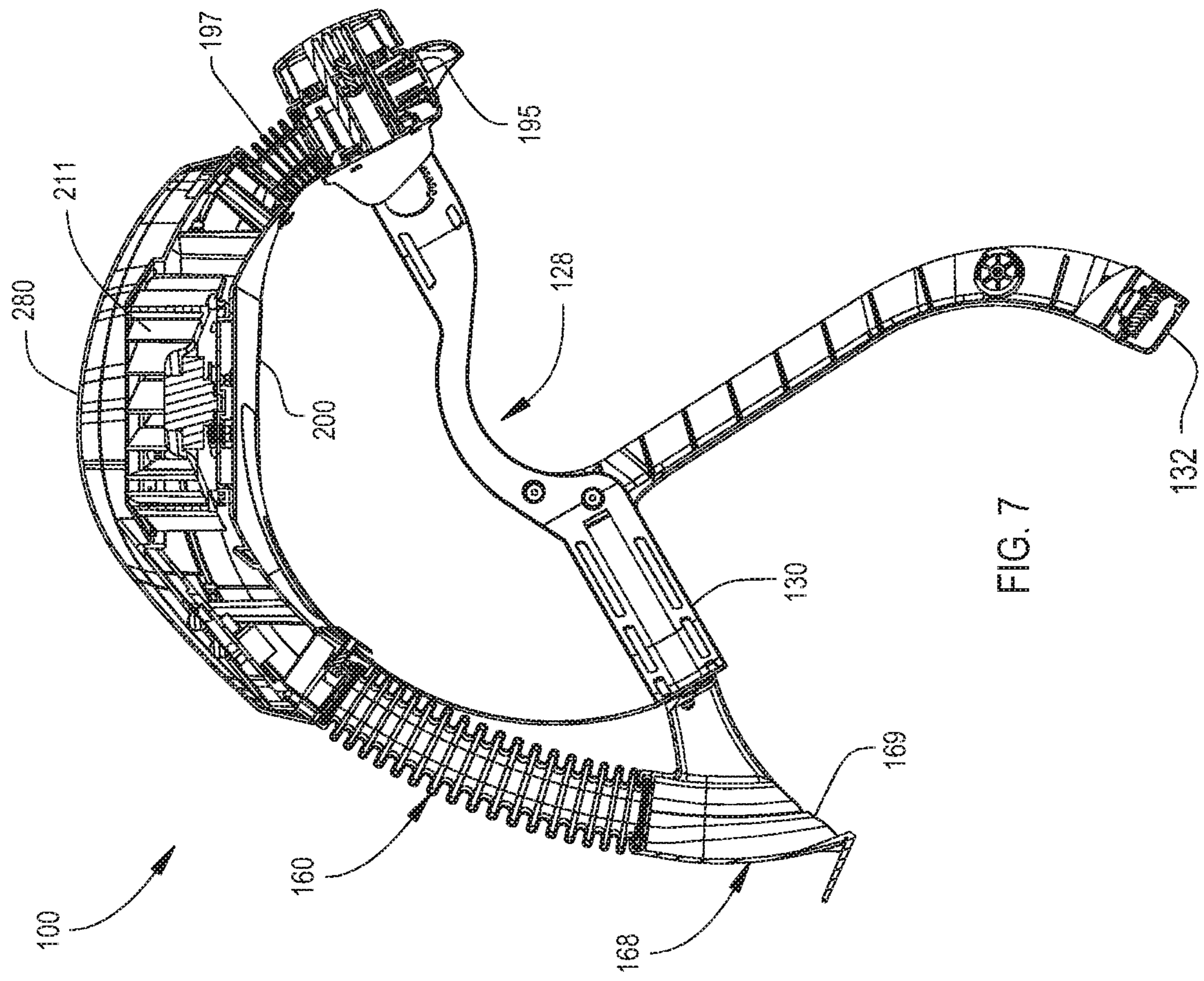
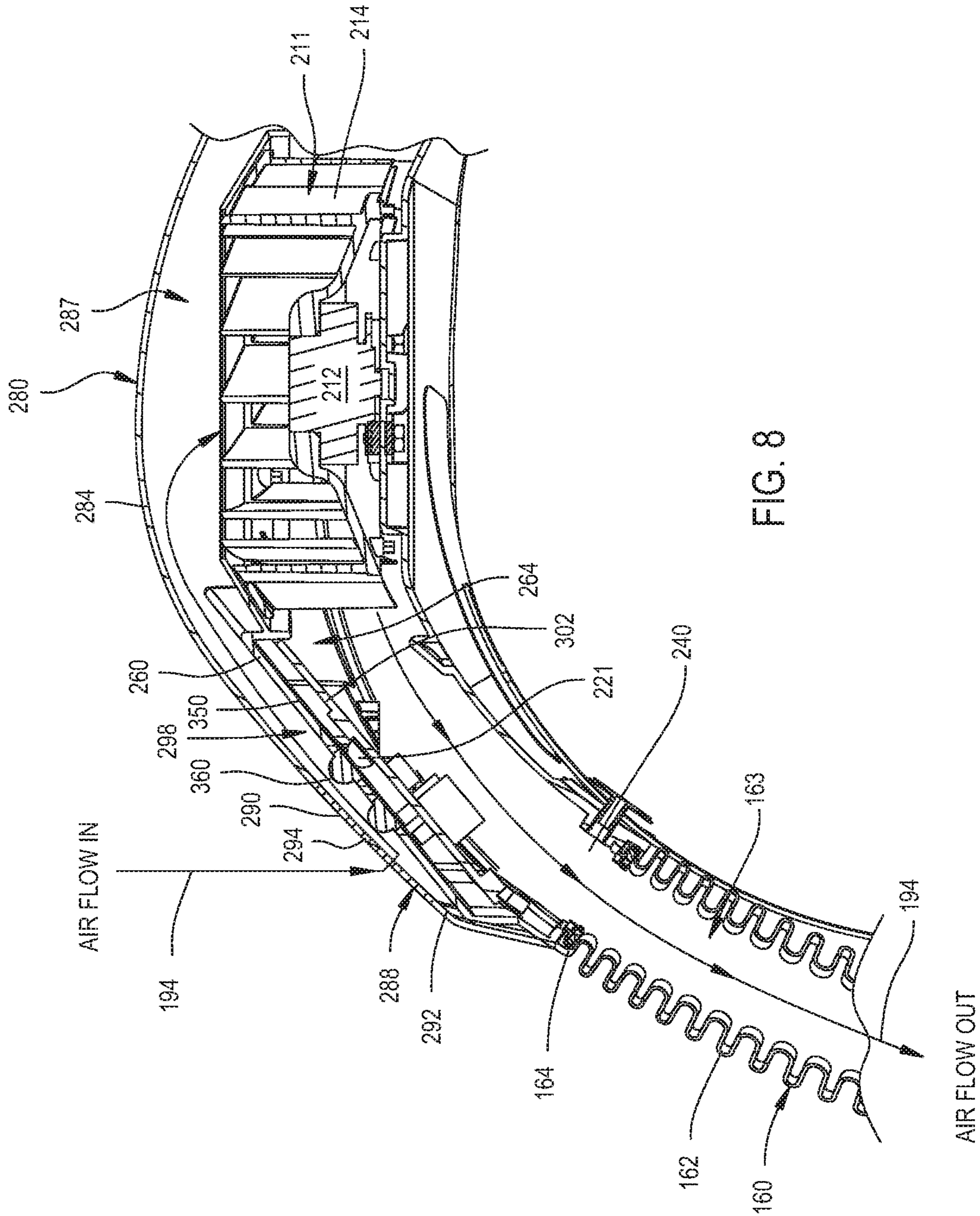


FIG. 7



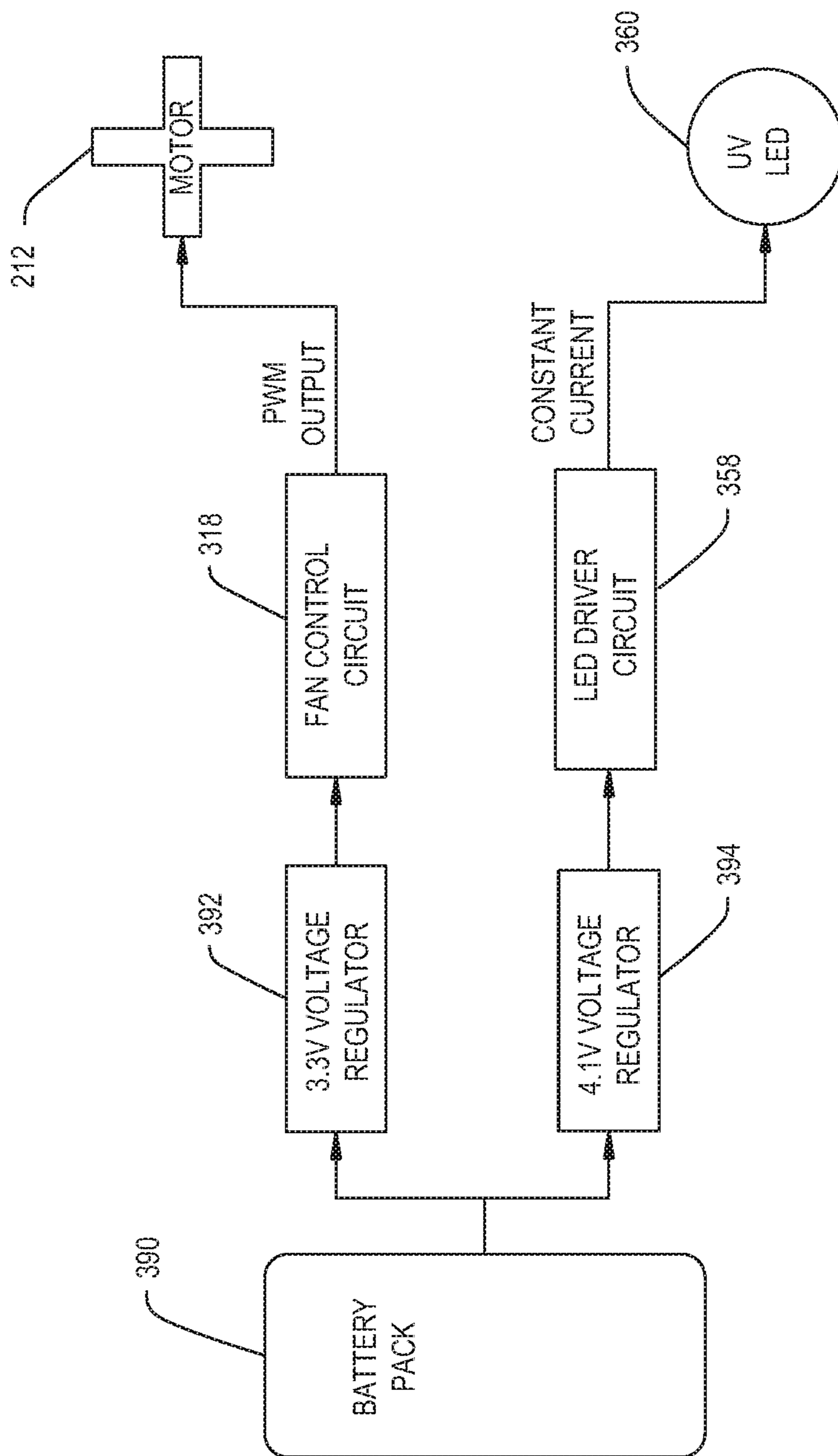


FIG. 9

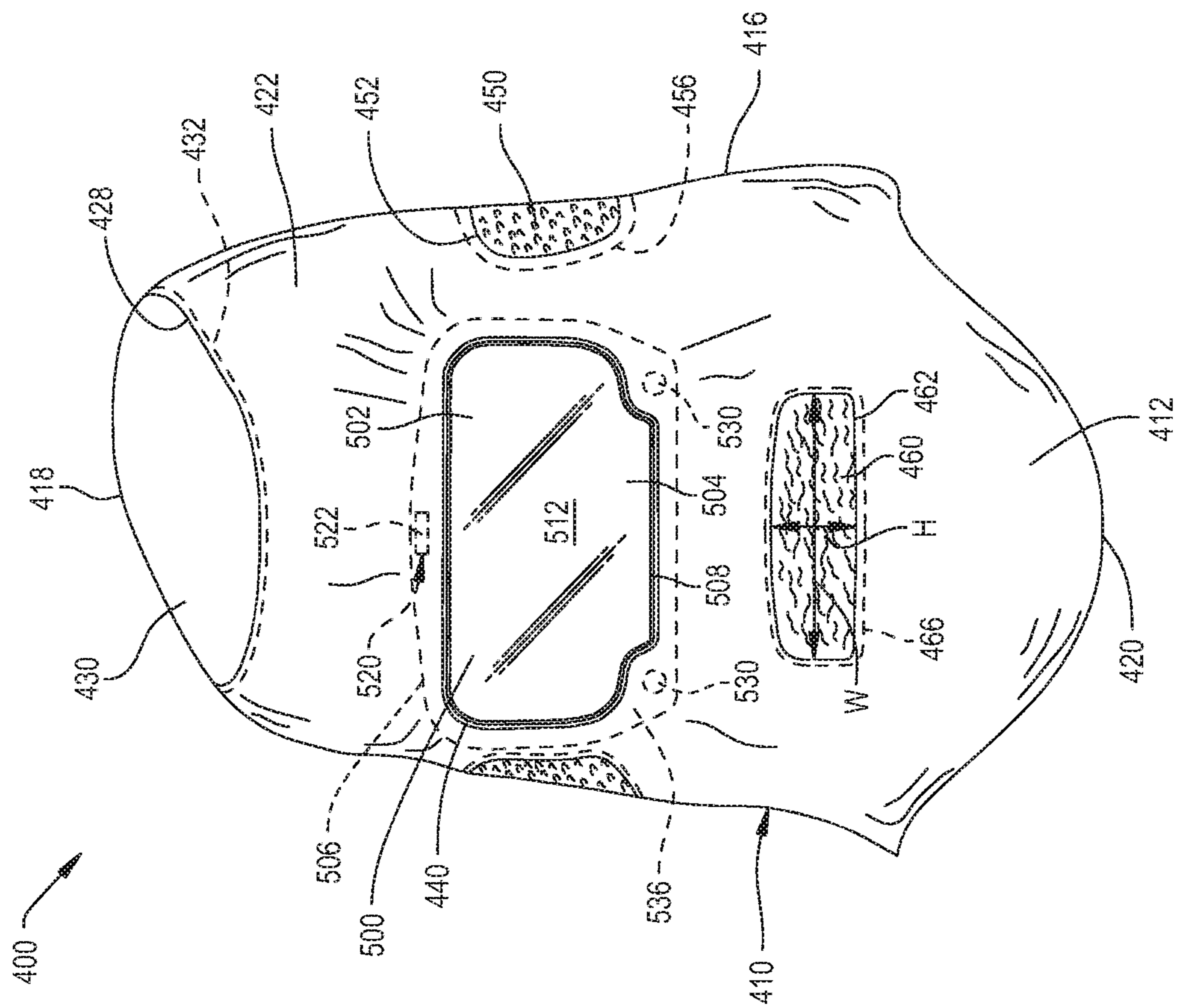


FIG. 11

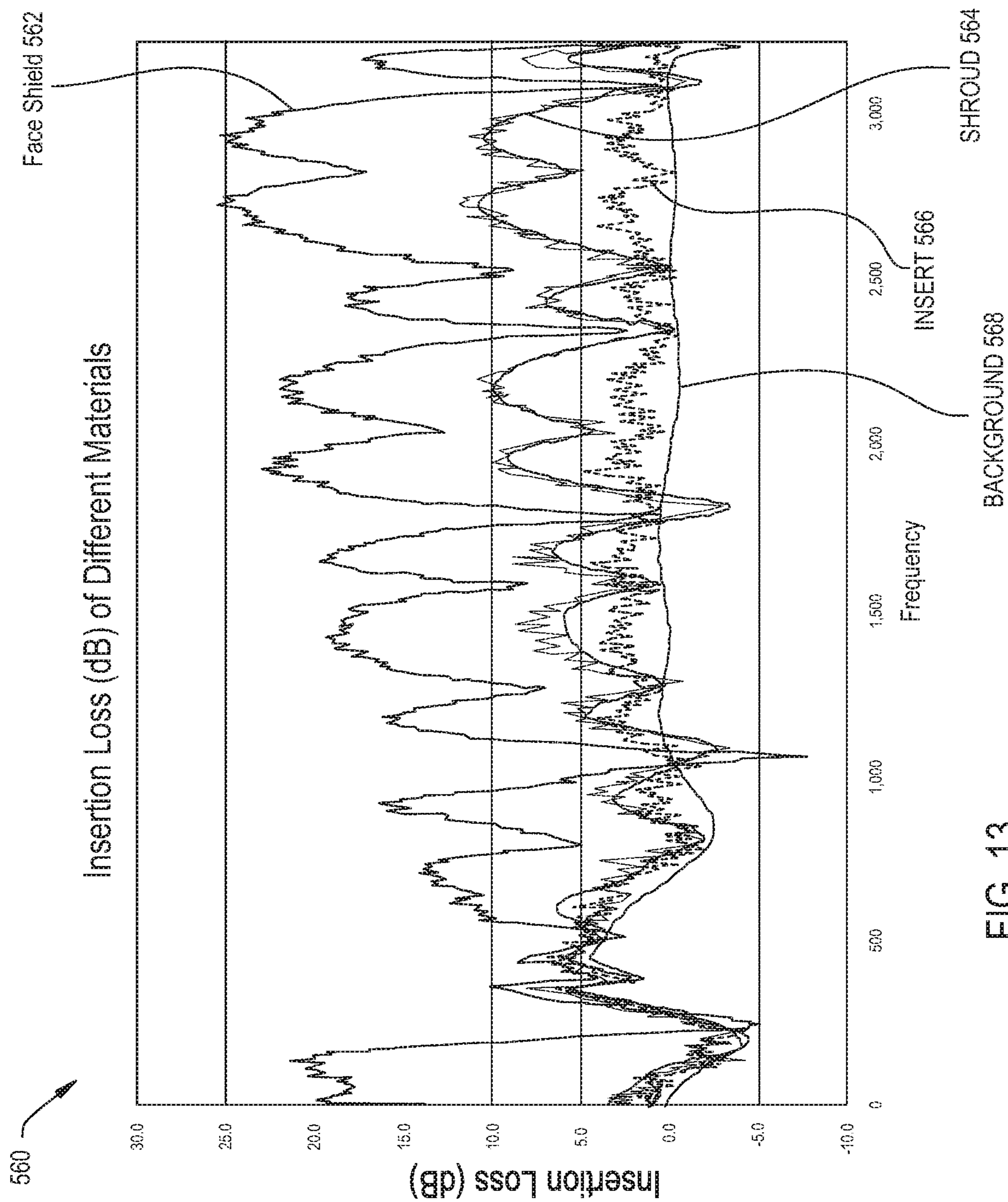


FIG. 13

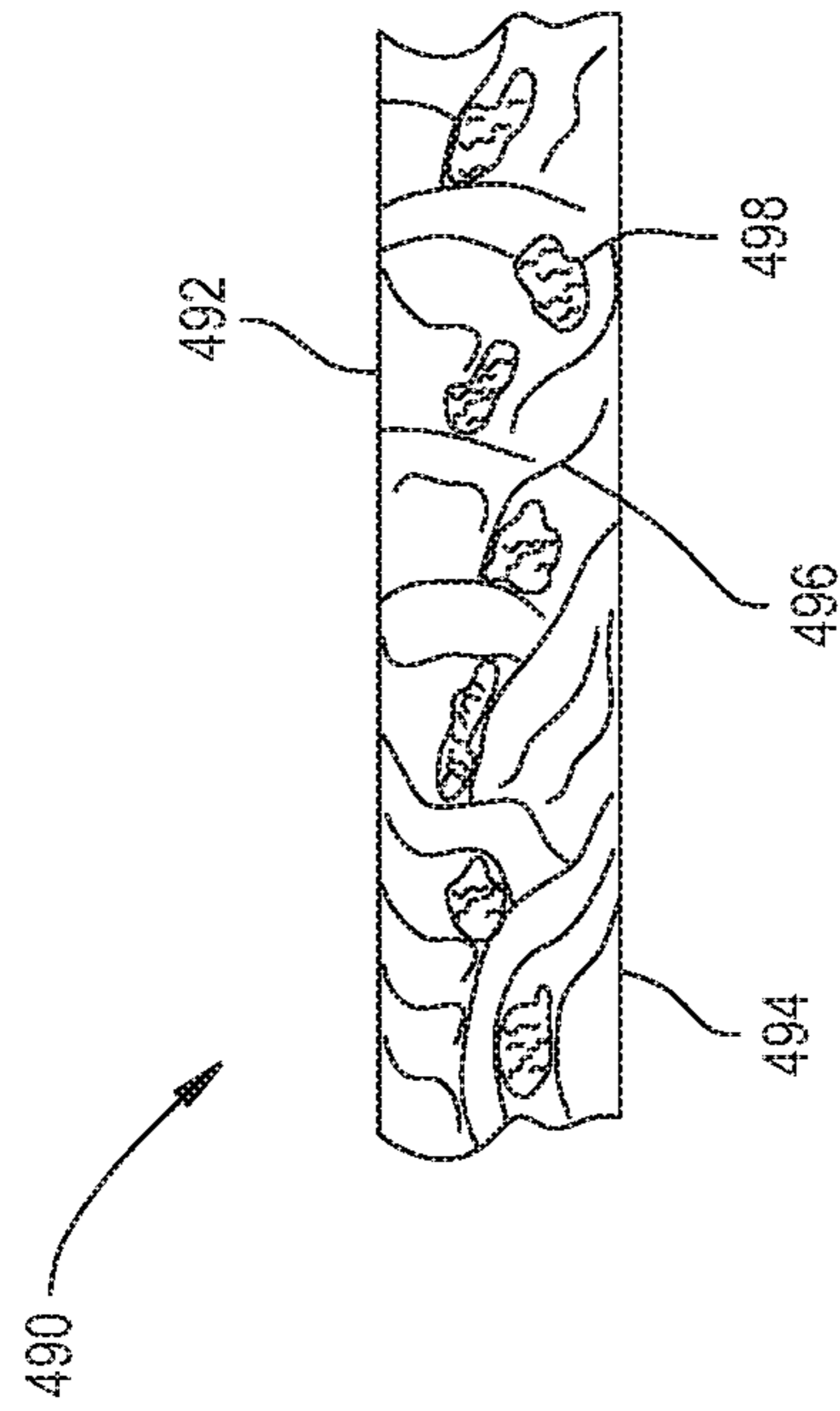


FIG. 14

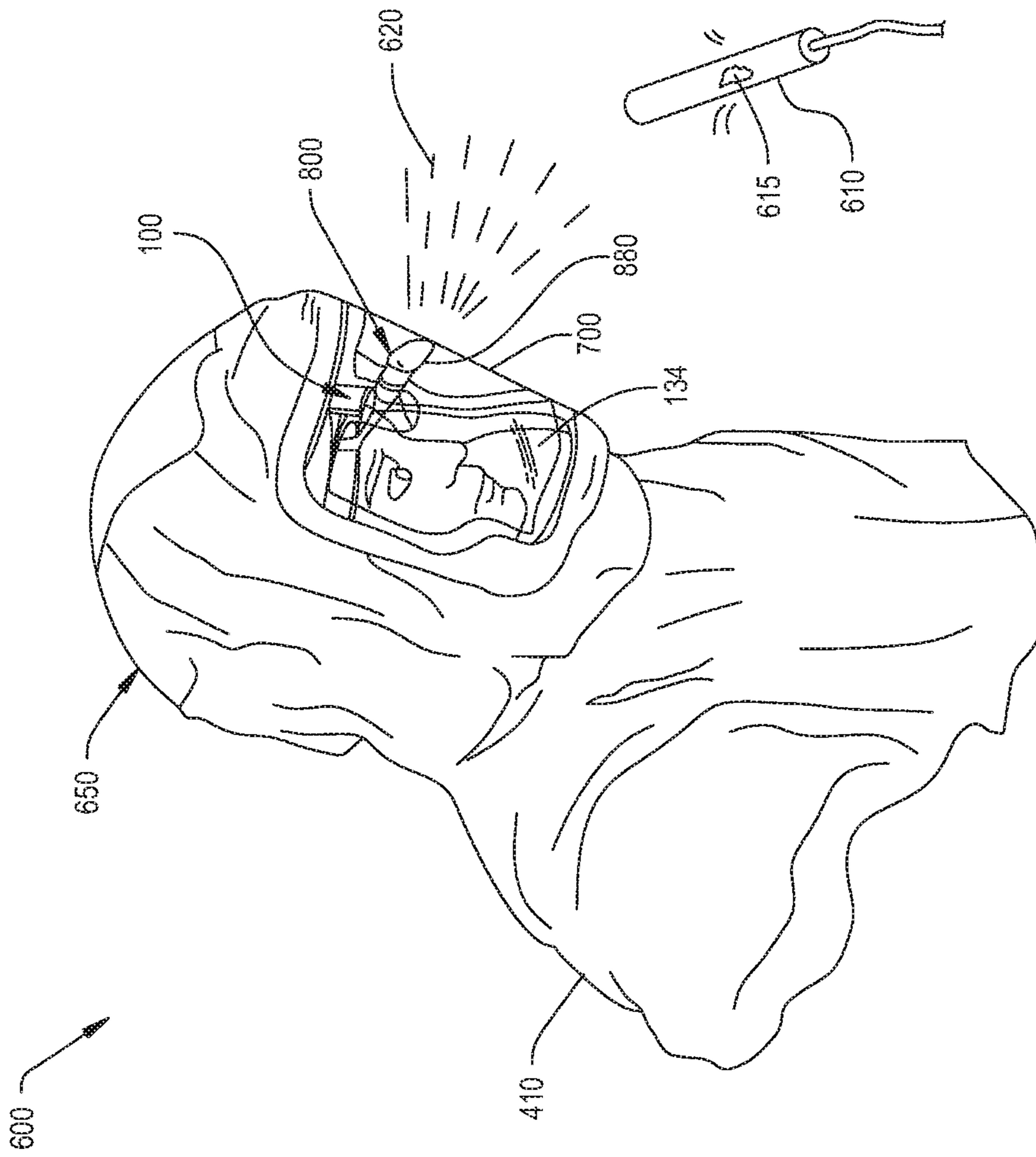


FIG. 15

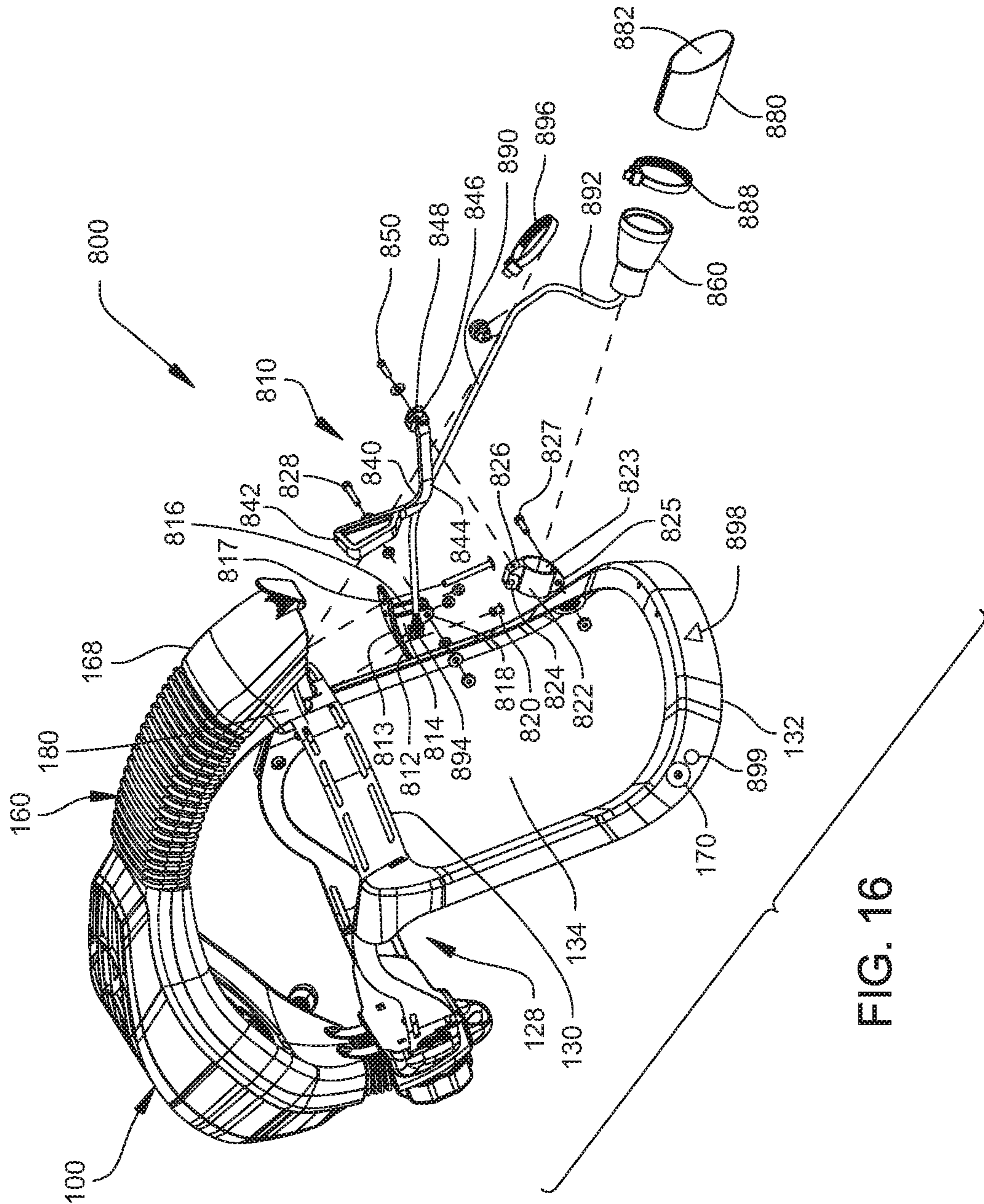


FIG. 16

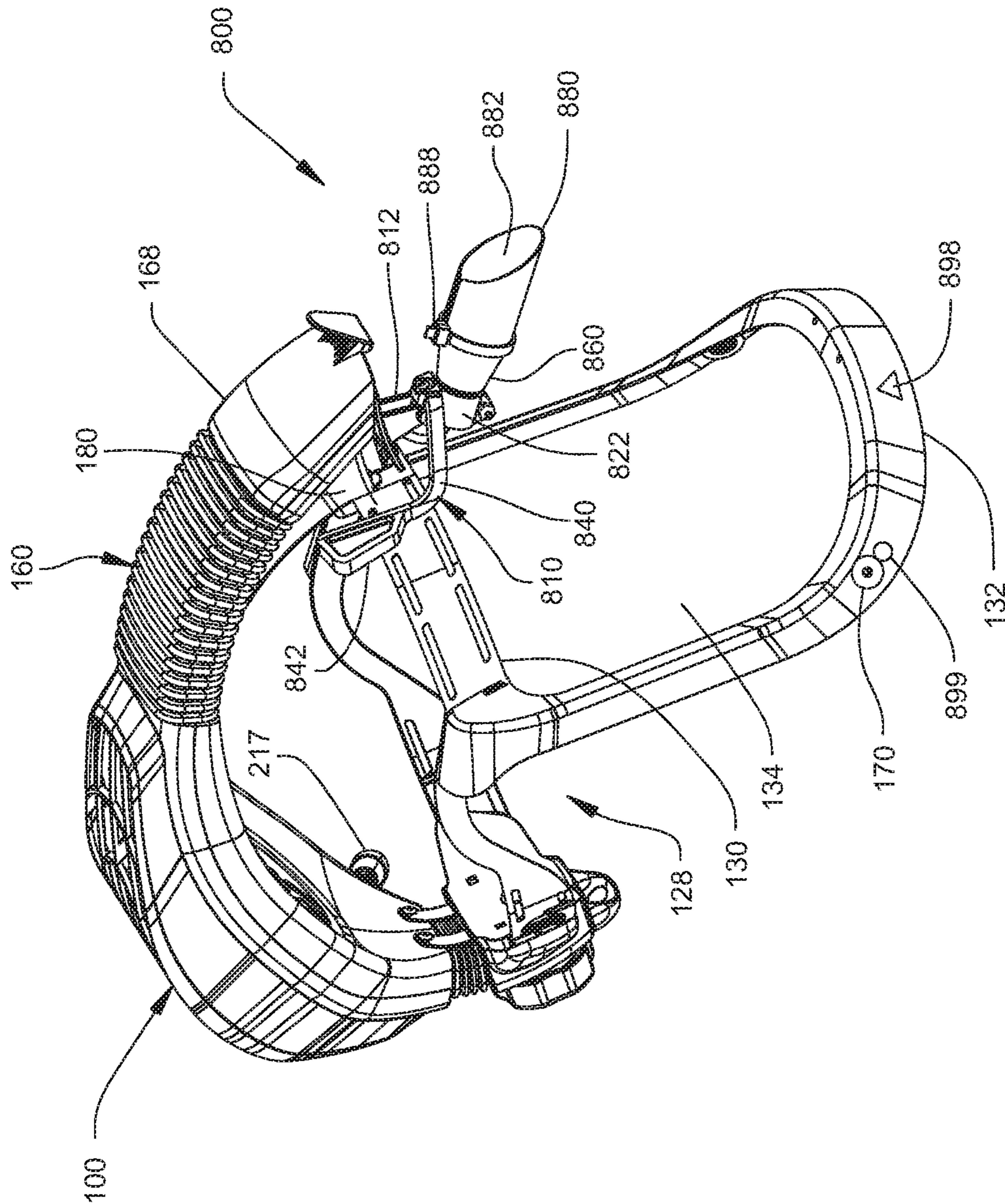


FIG. 17

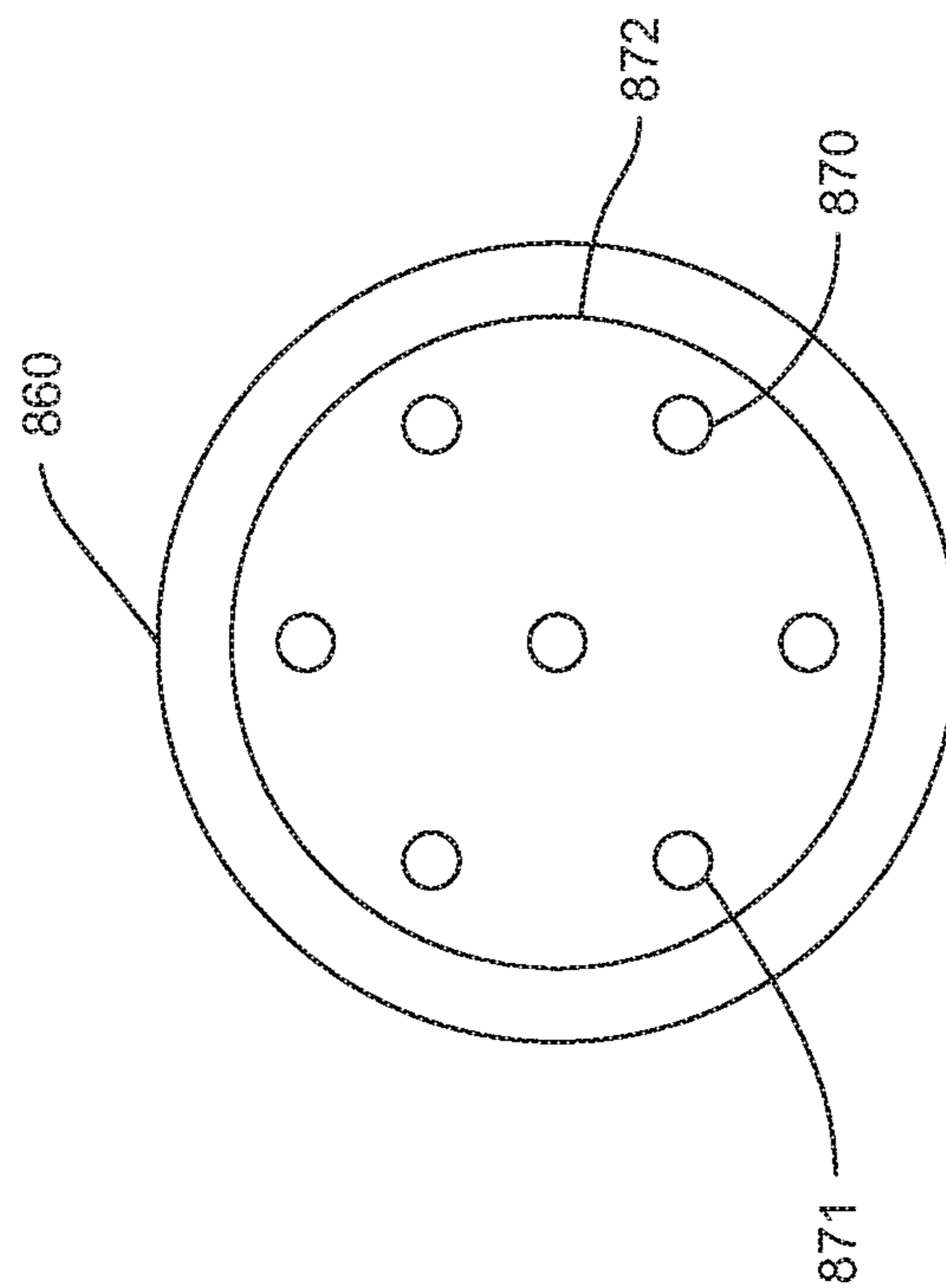


FIG. 18

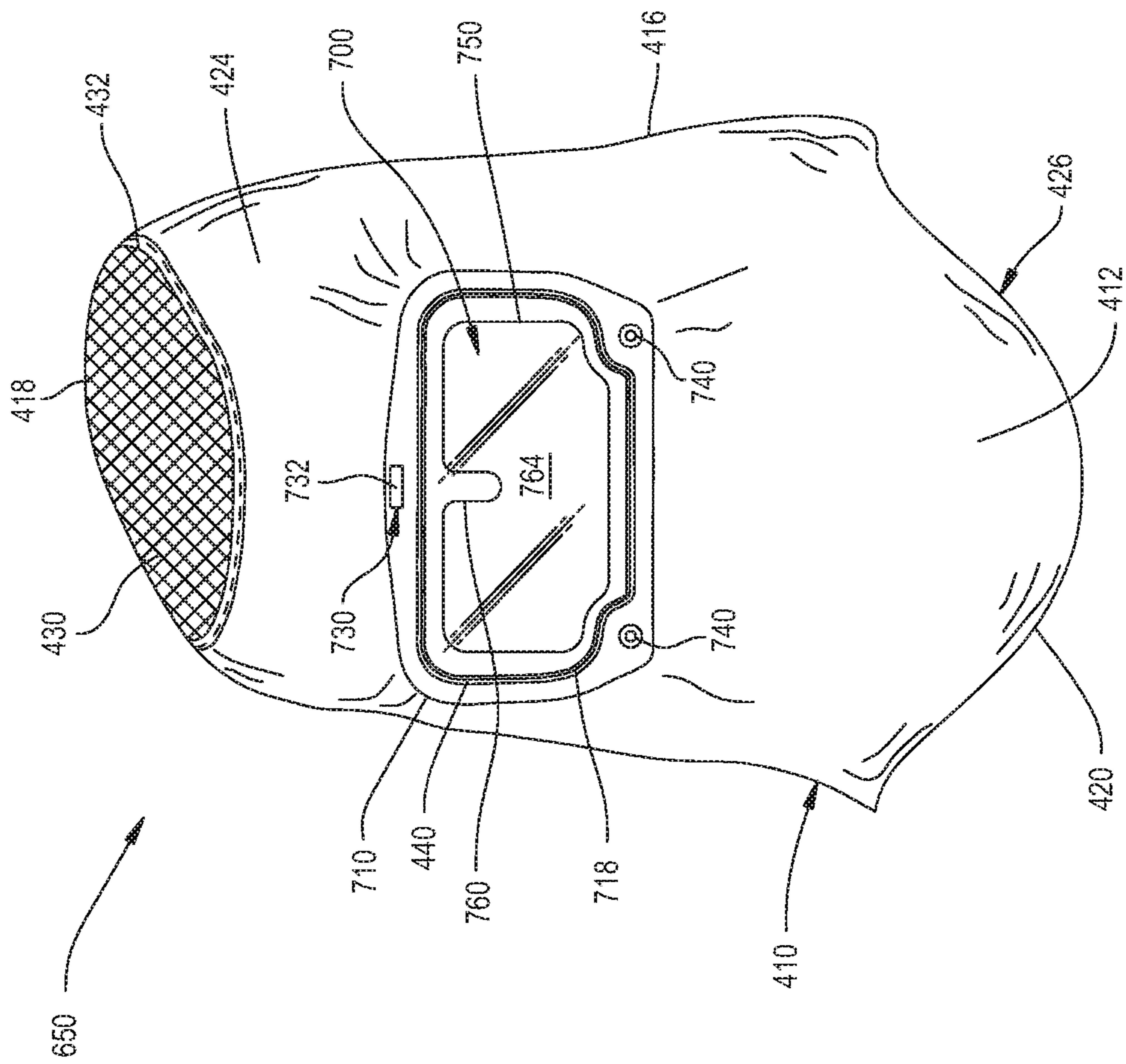
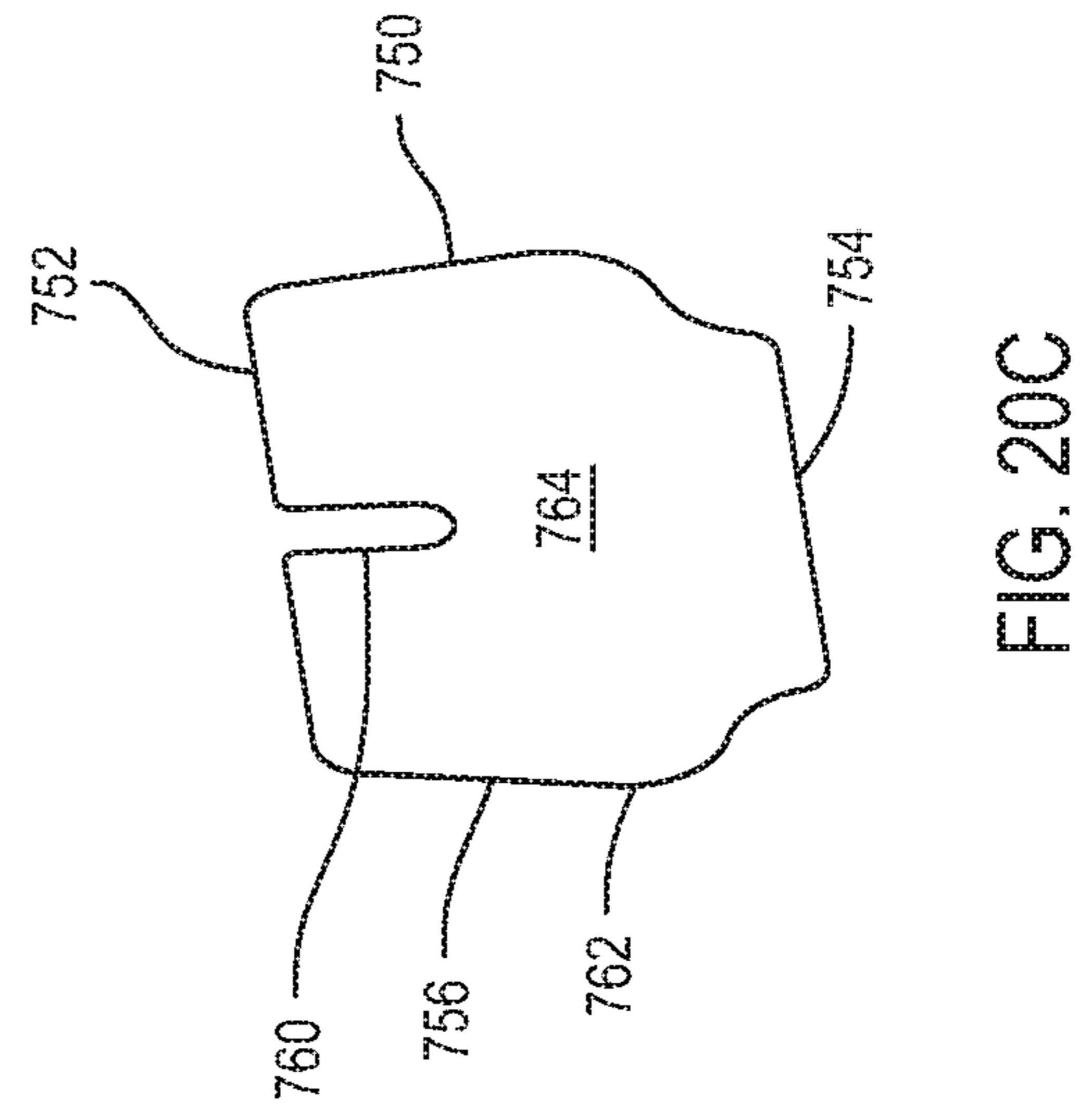
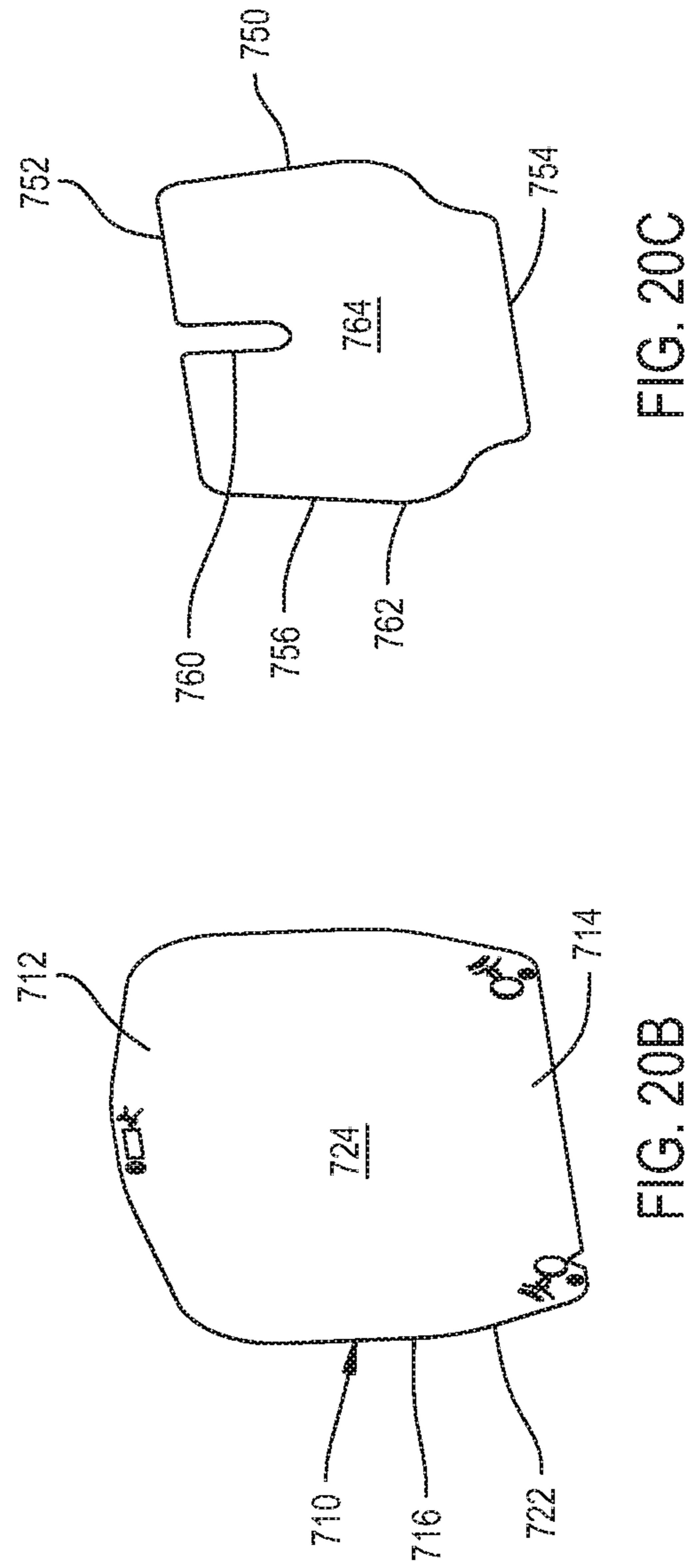
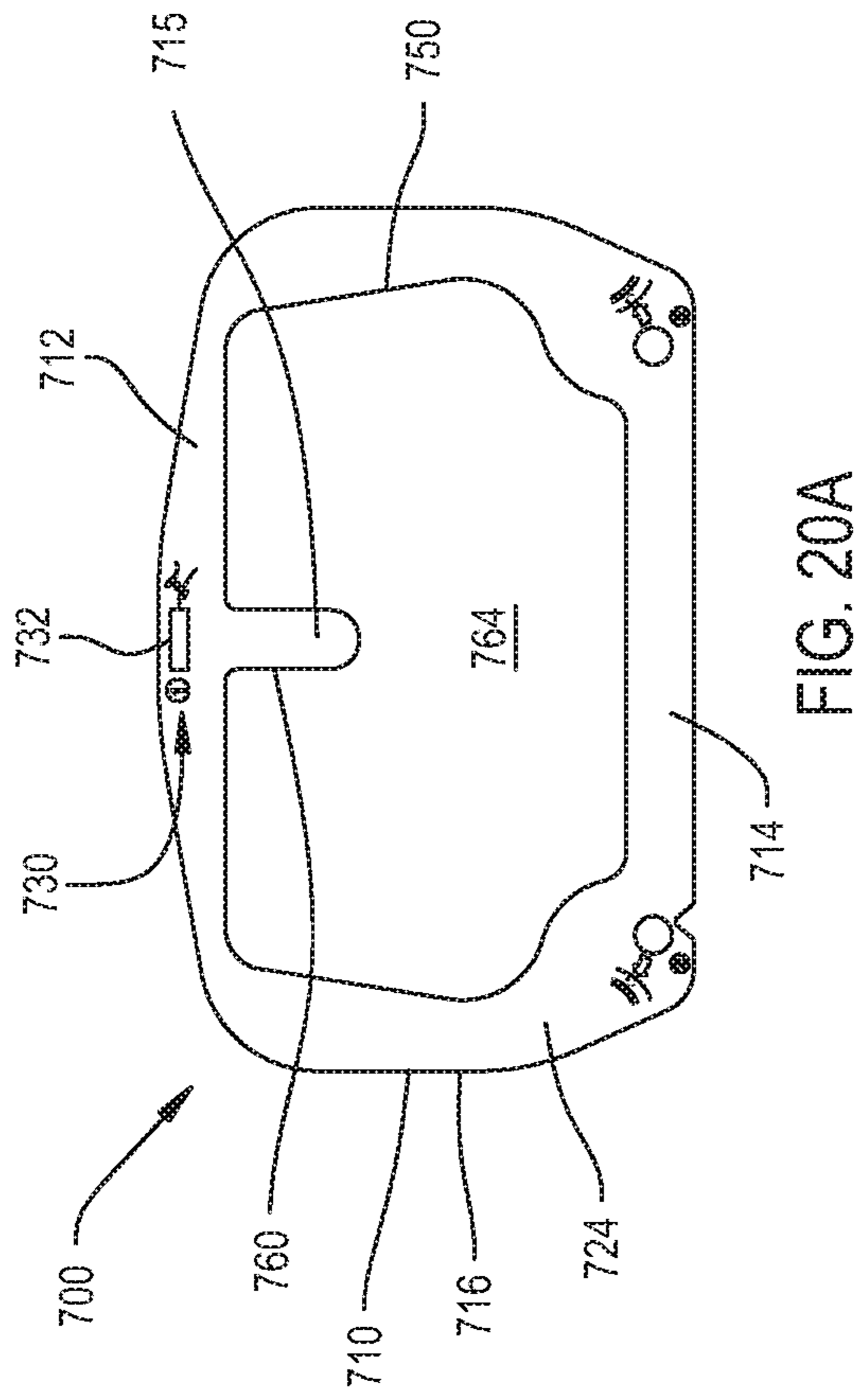


FIG. 19



900



FIG. 21

1

**PERSONAL PROTECTION SYSTEM
INCLUDING A HELMET WITH A SENSOR**

RELATIONSHIP TO PRIORITY APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/850,525 filed 10 Sep. 2015. U.S. patent application Ser. No. 14/850,525 is a continuation of PCT App. No. PCT/US2014/025919 filed 13 Mar. 2014. PCT App. No. PCT/US2014/025919 is a non-provisional of U.S. Provisional Pat. App. No. 61/783,234 filed 14 Mar. 2013. The above-listed priority applications are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Personal protection systems are used in surgical procedures to provide a sterile barrier between the surgical personnel and the patient. Examples of personal protection systems can be found in the Inventor's Assignee's U.S. Pat. No. 7,735,156 issued 15 Jun. 2010, U.S. Pat. No. 7,752,682 issued 13 Jul. 2010 and U.S. Pat. No. 8,234,722 issued 7 Aug. 2102 each of which is incorporated herein by reference.

The above identified patents disclose a personal protection system incorporating a helmet that supports a toga or a hood. This assembly is worn by medical/surgical personnel to establish a sterile barrier. The toga or the hood includes a transparent face shield. The helmet includes a ventilation unit that includes a fan. The ventilation unit draws air through the toga/hood so the air is circulated around the wearer.

The circulating air reduces both the amount of heat that is trapped within the toga/hood and the carbon dioxide that builds up under the toga/hood. Because the filter section of the toga/hood appreciably restricts airflow into the fan, a higher capacity fan than would otherwise be necessary is utilized. The larger capacity fan is also accompanied by an unwelcome higher level of noise during operation that is annoying and distracting to the user.

Further, because the air within a medical/surgical facility, such as an operating room, contains undesirable micro-organisms and pathogens, it is desirable to eliminate as many of the micro-organisms as possible before the air is breathed by medical personnel.

Personal protection systems of the prior art do a reasonable job of providing a sterile barrier between the surgical personnel and the surrounding environment. However, there are some limitations associated with their use. The toga/hood that covers the wearer blocks sound waves. This means an individual wearing the system may have to speak loudly or shout to be heard. This is especially the case when the hooded individual is trying to communicate with another individual similarly attired in an operating room environment.

Some personal protection systems have incorporated wireless transceivers or radios into the helmet to allow communication between medical personnel. The use of wireless transceivers adds appreciable cost and complexity to the personal protection system. Further, in a hospital setting with multiple users in adjoining surgical facilities, cross-talk and electromagnetic interference between wireless transceivers is a concern.

Personal protection systems can also be used in sterile processing departments (SPD) that clean, disinfect and sterilize previously used soiled surgical instruments and tools. The personal protection system protects the operator from

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biological hazards contained on the soiled surgical instruments. Surgical instruments and tools are sent to the SPD for sterilization after they are used in medical procedures. In the SPD, operators manually wash and clean the instruments and then load them into sterilizers to be heated and exposed to chemical sterilants. It is important for personnel working in the SPD to be able to visually detect any debris and bits of body tissue or medical waste that are retained to the surgical instruments in order to remove the contaminants during the cleaning process.

SUMMARY OF THE INVENTION

This invention is related to personal protection systems that provide protection to a user from an external environment. The personal protection system includes a helmet worn over the head of the user. The helmet has a head band that is disposed above the face of the wearer. A hood is disposed over the helmet. The hood has a transparent face shield that is forward of the head band and a filter for filtering air entering the filter from the external environment. A fastening assembly is integrated with the helmet to hold the hood, including the face shield over the helmet. A ventilation assembly is integral with the helmet. The ventilation assembly has a fan and a duct that is connected to the fan to convey air. The duct has an inlet section through which air is drawn and an outlet section through which air is discharged. An ultraviolet light assembly is coupled to the ventilation assembly. The ultraviolet light assembly is positioned to emit ultraviolet light into the duct so that air drawn through the duct is exposed to ultraviolet light. The ultraviolet light allows the use of a filter that is less restrictive to airflow.

The hood includes one or more openings that are dimensioned to receive a sound transmission insert that is mounted over the openings. The sound transmission insert is formed from a material that has a greater sound permeability than the material that forms the remainder of the hood.

Some versions of the invention include an inspection light assembly. The inspection light assembly includes an ultraviolet light source and is mounted to the helmet. The ultraviolet light source is positioned facing an interior surface of the face shield such that ultraviolet light from the ultraviolet light source is transmitted through the face shield. The face shield includes an ultraviolet blocking lens that prevents ultraviolet light external to the face shield from being transmitted through the face shield.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is pointed out with particularity in the claims. The above and further features and advantages of this invention are understood from the following Detailed Description taken in conjunction with the accompanying drawings in which:

FIG. 1 is an overall perspective view of a personal protection system with a hood draped over a helmet in accordance with one embodiment of the present invention;

FIG. 2 is front perspective view of the helmet of FIG. 1;

FIG. 3 is rear perspective view of the helmet of FIG. 1;

FIG. 4 is a partial exploded view of the helmet of FIG. 1;

FIG. 5 is another partial exploded view of the helmet of FIG. 1;

FIG. 6 is an enlarged exploded view of the lower shell and printed circuit boards;

FIG. 7 is a cross-sectional view of the helmet of FIG. 1;

FIG. 8 is an enlarged cross-sectional view of the helmet showing the air flow path;

FIG. 9 is an electrical block diagram illustrating the power circuit to the fan and lights;

FIG. 10 is a rear view of the face shield with the hood turned inside out illustrating the sound transmission inserts in accordance with one embodiment of the present invention;

FIG. 11 is a front view of the hood;

FIG. 12 is a left side view of the hood;

FIG. 13 is a graph of insertion loss versus frequency for several materials used in the fabrication of the hood;

FIG. 14 is a cross-sectional view of a filter section that incorporates activated charcoal;

FIG. 15 is an overall perspective view of a personal protection system with a hood draped over a helmet that has an attached inspection light assembly in accordance with one embodiment of the present invention;

FIG. 16 is a front perspective view of the helmet of FIG. 15 with the inspection light assembly in an exploded state;

FIG. 17 is a front perspective view of the helmet of FIG. 15 with the inspection light assembly in an assembled state;

FIG. 18 is a front plan view of a light housing containing ultraviolet light emitting diodes;

FIG. 19 is a rear view of the face shield of FIG. 15 with the hood turned inside out illustrating the face shield lens system in accordance with one embodiment of the present invention;

FIG. 20A is a rear view of the face shield lens system of FIG. 19;

FIG. 20B is a rear perspective view of the UV transmission lens;

FIG. 20C is a rear perspective view of the UV blocking lens; and

FIG. 21 is a graph of percent light transmission versus wavelength for several lens materials used in the face shield lens system.

DETAILED DESCRIPTION

I. Overview

Referring to FIG. 1, a personal protection system 50 is illustrated. Personal protection system 50 includes a head unit, helmet assembly or helmet 100 that is worn on the head of a user and a hood 400 with an integrated face shield 500 this is draped over the helmet. The system 50 creates a sterile barrier between the wearer and an external environment. The personal protection system 50 is useful in many medical environments, but is particularly adapted for use in surgery to protect patients from contamination during surgical procedures and to protect medical professionals from exposure to airborne contaminants and bodily fluids.

Hood 400 has a distal facing front section 412 and a proximal facing rear section 414. "Distal", it shall be understood means toward a surgical site that the wearer of personal protection system 50 is facing. "Proximal", means away from the surgical site that the wearer of personal protection system 50 is facing. Face shield 500 is mounted in distal facing front section 412.

II. Helmet With Ultraviolet Light

Positioned in the Air Flow Path

FIGS. 2-8 illustrate the helmet 100. The helmet 100 is generally adapted from the head units and helmets shown in Applicant's Assignee's U.S. Pat. No. 7,735,156 issued on Jun. 15, 2010, and U.S. Pat. No. 8,282,234 issued on Oct. 9, 2012, the entire contents of which are explicitly incorporated herein by reference.

The primary difference between the head units or helmets of these documents and the helmet 100 of the present invention is the addition of an ultraviolet light assembly 300 to the helmet 100. Otherwise, the head units or helmets disclosed in these references are suitable for use in the personal protection system 50 of the present invention.

The helmet 100 includes a support structure 128. The support structure 128 includes an adjustable head band 130 for mounting the helmet 100 to a head of the user. A generally U-shaped chin bar 132 depends downwardly from the head band 130 to define a facial opening 134. The chin bar 132 holds the hood 400 away from the face of the wearer.

A ventilation assembly 150 is coupled to support structure 128. Ventilation assembly 150 includes a lower shell 200 that faces the wearer, an upper shell 250 facing away from the wearer, an intake cover 280, and a fan 211. Lower shell 200 is attached to support structure 128. The upper shell 250 is attached to the lower shell 200. The upper shell 250 is spaced apart from the lower shell 200 to define at least one air flow channel 192 between the upper and lower shells. The shells 200 and 250 are formed of acrylonitrile butadiene styrene (ABS), polypropylene or other plastic materials.

Lower shell 200 is formed with several internal features. Lower shell 200 has a front end 202, a back end 203, a convex outer lower surface 204 and a concave inner surface 205. A peripheral side wall 206 extends upwardly away from the outer edges of inner surface 205. A semi-circular scroll housing wall 207 is formed with lower shell 200 and extends generally perpendicularly upwards from inner surface 205. Inner surface 205 and scroll housing wall 207 define a fan cavity 208. A printed circuit board cavity 210 is defined between inner surface 205, the front end 202 of lower shell 200 and a portion of scroll housing wall 207.

The fan 211 includes a fan motor 212 and fan blades 214. The fan motor 212 is attached to inner surface 205 within scroll housing wall 207. The fan blades 214 are coupled to the fan motor 212 and are disposed in fan cavity 208 slightly spaced from and surrounded by scroll housing wall 207. The fan motor 212 is electrically connected to a fan motor connector 215 that in turn is attached to fan motor cable 216. Fan motor cable 216 is connected to helmet external cable 217. Helmet external cable 217 is connectable with an external power source such as a battery. The rotation of fan motor 212 causes the like rotation of fan blades 214 in order to create a flow of air into personnel protection system 50.

Four mounting posts 218 are formed with lower shell 200 and extend generally perpendicularly away from inner surface 205. Two of the posts 218 are located at front end 202 and two of the posts 218 are located at back end 203. Mounting posts 218 receive fasteners 219. Fasteners 219, such as self tapping screws, retain upper shell 250 to posts 218 and lower shell 200. Three support arms 220 are formed with lower shell 200 and extend generally perpendicularly away from inner surface 205.

Upper shell 250 has a front end 252, a back end 253, a concave lower surface 254 and a convex outer surface 255. A peripheral side wall 256 extends downwardly away from the outer edges of surface 254. Fan opening 258 is defined in upper shell 250 and is positioned above fan blades 214. Four holes 259 are defined in upper shell 250. Two of the holes 259 are located toward front end 252 and the other two holes 259 are located toward end 254. Fasteners 219 extend through holes 259 and are received by posts 218 so that upper shell 250 is retained to lower shell 200.

A raised section 260 is formed with upper shell 250 and extends upwardly from outer surface 255. Raised section 260 is positioned between front end 252 and opening 258.

Raised section 260 includes a planar slanted top panel 262 and side walls 263 that extend downwardly from top panel 262 and connect to outer surface 255. The bottom side of top panel 262 and side walls 263 define a recessed area or recess 264 (FIG. 8). Light openings 266 are formed in top panel 262. While six light openings 266 are shown in FIG. 4, more or fewer light openings 266 can be defined in top panel 262. Raised section 260 further includes two diametrically opposed rectangular shaped slots 268 that are formed in side walls 263 and extend into outer surface 255.

Intake cover 280 is mounted to the upper shell 250. The intake cover 280 is contoured to match the shape of upper shell 250. Intake cover 280 has a front end 282, a back end 283 and a top wall 284 that is spaced from the outer surface 255 of upper shell 250. A peripheral side wall 286 extends downwardly away from the outer edges of top wall 284. The bottom side of top wall 284 and side wall 286 define a chamber 287.

An intake grid or grill 288 is defined in top wall 284 toward front end 282. Intake grill 288 is formed by a series of parallel rails or slats 290 that extend across an intake opening 292. A series of parallel slits 294 (best seen in FIG. 8) are shaped between the parallel slats 290. Air is drawn into the ventilation assembly 150 through the intake grill 288 by the fan 211. Specifically, air is drawn through slits 294 and into chamber 287 by fan 211.

Intake cover 280 is mounted over upper shell 250. Retention features 295 such as flexible snap fit tabs are formed with intake cover 280 and extend downwardly away from side wall 286. Retention features 295 fit into and mate with slots 268 of upper shell 250 to hold intake cover 280 to upper shell 250. A duct 298 (FIG. 8) is defined between the bottom side of top wall 284 and the top side of top panel 262. The slits 294, duct 298 and chamber 287 are all connected and contiguous with each other forming a unitary air flow path. Air is drawn through slits 294, duct 298 and chamber 287 by fan 211.

With continued reference to FIGS. 4 and 6, the ultraviolet light assembly 300 is now described. Ultraviolet light assembly 300 comprises a primary printed circuit board (PCB) 302 and a light emitting diode (LED) printed circuit board (PCB) 350. PCB 302 is generally trapezoidal shaped and has an upper surface 304 and a bottom surface 306. Two diametrically opposed notches 308 are defined in opposite sides of PCB 302. In one embodiment, primary PCB 302 is a multi-layered printed circuit board that has several printed circuit lines 310 (only one of which is shown in FIG. 6).

Primary PCB 302 is received by printed circuit board cavity 210 of lower shell 200. When primary PCB 302 is positioned in printed circuit board cavity 210, posts 220 extend through holes in primary PCB 302. With primary PCB 302 in printed circuit board cavity 210, the ends of posts 220 are heated and melted to form a heat stake 221 that extends over upper surface 304. Heat stake 221 holds primary PCB 302 to lower shell 200.

Electronic components are mounted to both the upper surface 304 and bottom surface 306 of primary PCB 302 and are interconnected by printed circuit lines 310. In an illustrative embodiment, a fan motor driver circuit 318 is mounted to bottom surface 306. Fan motor driver circuit 318 is communicatively coupled to fan motor 212 via a connector receiving unit 320. Connector receiving unit 320 is attached to the top surface 304 of primary PCB 302. The fan motor driver circuit 318 controls the operation of fan motor 212 including the rotational speed of fan blades 214.

Connector receiving unit 320 mates with connector insertion unit 326 to form one or more electrical connections.

Connector insertion unit 326 is attached to PCB cable 324. PCB cable 324 is retained to lower housing 200 and is connected to and in communication with fan motor cable 216 and external cable 217.

LED PCB 350 has a top side 352 and a bottom side 354. LED PCB 350 includes several printed circuit lines (not shown) that interconnect the electronic components mounted to LED PCB 350. The bottom side 354 of LED PCB 350 is electrically connected to the top side 304 of primary PCB 302 by suitable electronic assembly techniques such as soldering or wire bonding.

Six ultraviolet light emitting diodes (UVLED) 360 are mounted to the top side 352 of LED PCB 350. While six UVLEDs are utilized in the present example, more or fewer of UVLED 360 can be used. UVLED 360 are mounted to the top side 352 by suitable electronic assembly techniques such as soldering. Suitable ultraviolet light emitting diodes 360 are commercially available as model number LZ-100U600 from LED ENGIN Corporation having offices in San Jose, Calif.

In one embodiment, an LED driver circuit 358 is mounted to top surface 306 and is electrically connected to UVLEDs 360. LED driver circuit 358 functions to operate UVLEDs 360 supplying the required power and current levels. In one embodiment, LED driver circuit 358 supplies a constant current to UVLEDs 360 as the battery voltage drops preventing dimming of UVLEDs 360.

During assembly, upper shell 250 is mounted over primary PCB 302 and LED PCB 350 such that top panel 262 covers primary PCB 302 and LED PCB 350. PCB 302 and LED PCB 350 are disposed in recess 264. UVLEDs 360 extend through openings 266 and face into duct 298 (see FIG. 8). UVLEDs 360 are positioned below intake grid 288 and face slats 292 and slits 294.

Each ultraviolet light emitting diode 360 emits light in the ultraviolet frequency spectrum. Specifically, UVLED 360 emits ultraviolet (UV) light having wavelengths between 325 and 400 nanometers. Exposure to UV light can destroy or kill various pathogens such as bacteria, viruses, biological cells and fungal spores.

Turning to FIGS. 4, and 8, helmet 100 further comprises a nozzle assembly 160 that is attached to ventilation assembly 150. After upper shell 250 is mated with lower shell 200, a substantially rectangular shaped opening 240 is formed between front end 252 of upper shell 250 and front end 202 of lower shell 200. Nozzle assembly 160 includes a flexible elastomeric bellows 162 and a discharge nozzle 168. Bellows 162 expands and contracts and has an internal conduit 163.

The conduit 163, sometimes referred to as a duct, carries forced air from fan 211 to discharge nozzle 168. Bellows 162 has an upper end 164 that is connected to shell ends 240 and 252 such that conduit 163 is contiguous with opening 240. The lower end 165 of bellows 162 is coupled to discharge nozzle 168. Discharge nozzle 168 has an outlet 169. Air from fan 211 is discharged through outlet 169.

Helmet 100 also includes a rear nozzle, nozzle 195. Nozzle 195 is mounted to the headband so as to be directed towards the neck of the wearer. A rear bellows 197 extends from the rear end of the lower and upper shells 200 and 250, respectively. The bellows 197 defines the conduit, the duct, through which air discharged by the fan is flowed to the rear nozzle 195.

In operation, the fan motor 212 rotates the fan blades 214 to draw air through slits 294, duct 298, and chamber 287 into fan 211. The air is discharged from fan 211 through channel 192 (FIG. 6), opening 240, conduit 163, exiting at discharge

nozzle opening 169 (FIG. 4). Slits 294, duct 298, chamber 287, channel 192 opening 240, conduit 163 and discharge nozzle opening 169 all form a continuous air flow path 194. The air flowing through discharge opening 169 is directed toward the user's head and face providing fresh purified air to the user. A fraction of the air forced through the ventilation assembly also through the rear bellows 197. This air is flows through and discharged from the rear nozzle 195.

Because UVLEDS 360 (FIG. 8) are positioned below intake grid 288 and face slits 294 and face into duct 298, the incoming air to the helmet 100 is exposed to ultraviolet light generated by UVLEDS 360. Micro-organisms entrained with the incoming air are subjected to UV light exposure causing the micro-organisms to be rendered harmless or innocuous. Collectively, the components forming helmet 100 are designed so that the air drawn into the system 50 and discharged through the outlet ducts is exposed to UV light for a time period of at least 0.05 seconds, more ideally, at least 0.1 seconds and more ideally still at least 0.25 seconds. By way of example, exposing the air stream containing the influenza A virus to UV light using the above-described configuration of the invention for at least 0.1 second is believed to render at least at least 50% of the viruses innocuous. Exposing the air stream containing the influenza A virus to UV light using the above-described configuration of the invention for at least 0.25 seconds is believed to render at least at least 99% of the viruses innocuous.

Owing to the use of UV light assembly 300 and UVLEDS 360, the filter section 430 (FIG. 10) of hood 400 (FIG. 10) can be formed from a less restrictive filter material than would otherwise be required to purify incoming air to personal protection system 50. When UVLEDS 360 are used, filter section 430 has a higher air flow transmission rate because the ultraviolet light functions to eliminate pathogens in the incoming air that were able to pass through filter section 430.

With the light assembly 300 and UVLEDS 360 positioned in the flow of incoming air, the flowing air removes heat generated by light assembly 300. This air is exhausted out of hood 400 (FIG. 10), reducing the buildup of heated air adjacent the light assembly 300 and improving comfort of the user of personal protection system 50.

FIG. 9 illustrates electrical circuits for fan motor 212 and UVLEDS 360. A battery 390 provides electric power to both fan motor 212 and light assembly 300. Battery 390 can be either a rechargeable battery or non-rechargeable (i.e. disposable) battery. In one embodiment, battery 390 is a 6 volt DC battery. The battery 390 is worn by the user on a belt or clipped to clothing and is attached to external cable 217 (FIG. 2) in order to supply power to helmet 100.

Battery 390 is connected to a power supply circuit including a 3.3 volt voltage regulator circuit 392. Voltage regulator circuit 392 is connected to fan control circuit 318, which in turn is connected to fan motor 212 via cable 216 (FIG. 6). Voltage regulator 392 applies a constant 3.3 volts to fan control circuit 318 for energizing the control circuit. Fan control circuit 318 drives fan motor 212. Fan control circuit 318 controls the rotational speed of fan 211. A switch button (not shown) can be mounted to helmet 100 to turn fan 211 on and off.

Battery 390 is also connected to a 4.1 volt voltage regulator 394. Voltage regulator 394 is connected to the LED driver 358, which in turn is connected to UVLEDS 360 through PCBs 302 and 350 (FIG. 6). Voltage regulator 394 applies a constant 4.1 volts to LED driver circuit 358 for energizing the UVLEDS 360. LED driver circuit 358 drives UVLEDS 360. LED driver circuit 358 turns UVLEDS 360

on an off. In one embodiment, UVLEDS 360 are turned on whenever fan 211 is operating. In another embodiment, a switch button (not shown) allows a user to selectively turn UVLEDS 360 on and off.

Voltage regulator circuits 392 and 394, fan control circuit 318 and LED driver circuit 358 are all mounted to primary PCB 302 (FIG. 6). Primary PCB 302 is electrically connected to battery 390 via connector 326, 320, PCB cable 324 and external cable 217.

III. Hood and Shell With

Improved Sound Transmission

Referring to FIGS. 10-12, the hood 400 is shown. FIG. 11 illustrates an outside view of the hood 400, while FIG. 10 shows the hood 400 in a position turned inside out depicting the interior of hood 400. In the illustrated version of the invention the hood is formed to not extend beyond the shoulders of the individual wearing the system 50. In one embodiment, the hood is a hood 400 that drapes over the helmet 100 and terminates just over the wearer's shoulders. In another embodiment, the hood 400 is part of a toga. A toga is a garment with covers at least the chest and arms of the individual wearing the personal protection system 50. Often a toga is designed to extend to at least the knees of the person wearing the toga.

The hood 400 includes a flexible shell 410. Shell 410 is formed from a barrier fabric such as a multi-laminate nonwoven material comprised of polyethylene, polypropylene, or polyester, or any combination thereof. More specifically, the material from which the shell 410 is formed is material that prevents fluids and particulate from passing therethrough. Shell 410 has a distal facing front section 412, a proximal facing rear section 414, side sections 416, a top 418 and a bottom 420. Shell 410 includes an outer surface 422, an interior surface 424 and an interior space 426 that is defined by interior surface 424. An oval shaped filter opening 428 is defined in the top 418 of the shell and a face shield opening 440 is defined in the front 412 of the shell.

A filter section 430 is mounted over opening 428 and is attached to shell 410 at the edges of opening 428. In one embodiment, filter section 430 is attached to shell 410 by sewing techniques using thread to form a seam 432. In another embodiment, filter section 430 is attached to the shell 410 by an adhesive. Filter section 430 slightly overlaps shell 410 onto interior surface 424. Intake cover 280 (see FIG. 4) spaces the filter section 430 out away from the ventilation assembly 150.

Due to the use of UV light assembly 300 (FIG. 4) and UVLEDS 360 (FIG. 4), filter section 430 is formed from a less restrictive filter material than would otherwise be required to purify incoming air to personal protection system 50. Filter 430 is formed from a medium such as a meltblown or triboelectret nonwoven fabric having porosity suitable for filtering particles of 0.1 microns or greater from air entering the shell 410 from the external environment. This fabric is less restrictive than the fabric from which filters for conventional hoods are formed. Owing to the relatively less restrictive nature of the material forming filter 430, system 50 does not require the same relatively high vacuum draw to pull the same volume of air into the hood as a system with hood having a conventional filter section.

Thus in a version of the invention in which the air flow across filter 430 is at rate of 425 l/min, the pressure drop across the filter is typically a maximum of 5 Pascals and more often a maximum of 3 Pascals. In comparison, the pressure drop across a filter of a conventional personal protection system at the above air flow rate is at least 10 Pascals

The less restrictive filter section **430** allows for a lower speed fan to be used in helmet **100**, while still providing the same volume of air flow. A lower speed fan is quieter and more comfortable environment for the wearer than the fans of the conventional personal protection systems.

Turning to FIG. **14**, a cross section of an alternative filter **490** is shown. Filter **490** is similar to filter **430**. Filter **490** further includes activated charcoal particles **498** embedded into the nonwoven filter medium **496**. Filter section **490** includes a top surface **492** and a bottom surface **494**. Activated charcoal particles **498** are embedded between top surface **492** and bottom surface **494** within the nonwoven filter medium material **496**.

The filter medium **496** is the same material from which filter **490** is formed and can have the same porosity. The embedded activated charcoal particles **498** trap smoke and odors in the air generated during normal surgical activities such as tissue cauterization.

A flexible and transparent face shield **500** permits the user to see or view through the hood **400**. As shown in FIG. **1**, the face shield **500** is mounted to distal facing front section **412** such that the face shield **500** covers the facial opening **134** of the helmet **100** after the user dresses into the personal protection system **50**. The facial opening **134** of the helmet **100** receives the face shield **500**.

Referring specifically to FIGS. **10-12**, the face shield **500** includes a top portion **502**, a bottom portion **504**, an outer peripheral edge **506** and a sealing perimeter **508**. Face shield **500** further has a distal facing outer surface **512** and a proximal facing interior surface **514**. The top portion **502** defines the top one-half of the face shield **500** and the bottom portion **504** defines the bottom one-half.

Face shield **500** is mounted over opening **440** slightly overlapping inside surface **424**. The shell **410** is sealed to the face shield **500** on an outside surface **512** of the face shield **500** along the sealing perimeter **508**. The shell **410** can be sealed to the face shield **500** by suitable means such as using an adhesive or by welding. The face shield **500** is preferably formed of a sterilizable material. In one embodiment, the face shield **500** is formed of Lexan® 8010 having a thickness of approximately 15 mils.

An upper mounting element **520** is disposed on the face shield **500** along the top portion **502**. The upper mounting element **520** is centered on the face shield **500** along the top portion **502**. The upper mounting element **520** is a rectangular shaped aperture **522** defined through the face shield **500**. The upper mounting element **520** is configured for fastening to an upper mounting device **184** (FIG. **2**) included on the helmet **100**. The upper mounting device **184** is centered on the helmet **100** relative to the facial opening **134**. The upper mounting device **184** is a single mounting clip **186** (FIG. **2**) connected to the helmet **100**, and that is positioned in a centered relationship relative to the facial opening **134**.

As best shown in FIG. **2**, the mounting clip **186** extends upwardly from a front nozzle assembly **160** of the helmet **100** away from the facial opening **134** to support the face shield **500**. The mounting clip **186** includes a distal edge **190** extending outwardly from the nozzle assembly **160** such that a portion of the face shield **500** rests between the distal edge **190** and the nozzle assembly **160** after the face shield **500** is mounted to the mounting clip **186**. The mounting clip **186** interlocks with the aperture **522** on the face shield **500** to automatically center the face shield **500** over the facial opening **134**. Specifically, the mounting clip **186** protrudes through aperture **522** when mounting the face shield **500** to the helmet **100**.

Turning to FIGS. **2**, and **10-12**, two lower mounting elements **530** are disposed on the face shield **500** along the bottom portion **504** inner surface **514** and facing in a proximal direction. The lower mounting elements **530** are magnets or are formed of magnetically attractive material. In one embodiment, the lower mounting elements **530** are steel rivets mounted to face shield **500**. The lower mounting elements **530** are configured to fasten to lower mounting devices **170** on the chin bar **132** of the helmet **100** to secure the bottom portion **504** of the face shield **100** to the chin bar **132**. The lower mounting devices **170** are preferably magnets or are formed of magnetically attractive material configured to attract the lower mounting elements **530**.

Mounting elements **522** and **530** are preferably mounted along an outer portion **536** of the face shield **500**. The outer portion **536** is defined between the outer peripheral edge **506** the face shield **60** and the sealing perimeter **508**. As a result, when the shell **410** is glued or adhered to the face shield **500** along the sealing perimeter **508**, the upper **520** and lower **530** mounting elements are hidden beneath the shell **410**, out of view from an external perspective.

With reference to FIG. **1**, hood **400** further includes passive communication aids to assist the wearer in communicating with others in the vicinity. Hood **400** has a pair of diametrically opposed sound transmission inserts **450** to allow the wearer of hood **400** to more easily hear sounds generated external to hood **400**. Inserts **450** are positioned to be adjacent the ears of the wearer. A sound transmission insert **460** facilitates the transmission of speech (sound waves) generated by the wearer to the space outside of the hood **400**. Insert **460** is positioned to be in front of the mouth of the wearer. Sound waves are transmitted with less distortion, a smaller insertion loss, through ear sound inserts **450** **460** than through the fabric forming the shell **410** of the hood.

Ear and mouth sound transmission inserts allow a wearer of shell **410** to readily communicate with other personnel who are also wearing personal protection system **50**. The use of ear and mouth sound transmission inserts **450**, **460** can eliminate the need for active communication aids such as radios by the wearer.

As seen in FIGS. **10-12**, a pair of diametrically opposed, generally round openings **452** are formed in side sections **416** of shell **410**. Each opening is adjacent where the shell is located adjacent an ear. Openings **452** extend entirely through side sections **416**. Each transmission insert **450** includes an outer circumferential or perimeter edge **456**. The ear sound transmission insert **450** is mounted over opening **452** in a slightly overlapping relationship to inside surface **424**. The insert **450** is sealed to shell side sections **416** along perimeter edge **456**. Inserts **450** are sealed to shell **410** by suitable means such as by adhesive bonding, ultrasonic welding, heat sealing or by sewing.

Each insert **450** has a height H, defined within the opening **452**, of at least 5 cm and a width W, perpendicular to the height H, defined within the opening **452** of at least 5 cm. In particular, the width W provides a suitable listening area for the wearer to hear activities occurring to the front, side and back of the wearer.

A generally oval or oblong shaped mouth opening **462** is formed in the distal front section **412** of shell **410**. Mouth opening **462** extends through front section **412** of shell **410**. Insert **460** includes an outer peripheral edge **466**. The mouth sound transmission insert **460** is mounted over opening **462** in a slightly overlapping relationship to inside surface **424**. The mouth sound transmission insert **460** is sealed to shell front section **412** along peripheral edge **466**. The mouth

sound transmission insert **460** is sealed to shell **410** by the same means by which the inserts **450** are mounted to the shell.

The mouth sound transmission insert **460** has a height H, defined within the opening **462**, of at least 10 cm and a width W, perpendicular to the height H, defined within the opening **462** of at least 5 cm. In particular, the width W provides a suitable area for the sound waves generated by the wearer to pass through the hood **400**.

Inserts **450** and **460** are formed of material that is relatively permeable to the transmission of sound waves. In one embodiment, inserts **450** and **460** are formed from a melt-blown nonwoven material such as polypropylene. The material from which the inserts **450** and **460** is formed is also selected so as to form a barrier that would prevent the penetration of liquid state contaminants through the hood.

FIG. **13** illustrates a graph **560** of sound insertion loss versus frequency for several different materials used in hood **400**. Graph **560** compares the sound transmission of the different materials used in hood **400**. The frequency range for human speech (i.e. the frequencies heard by the ear) is defined as between 85 to 3400 Hertz. Graph **560** illustrates the insertion loss in decibels (dB) over the frequency range of 0 to 3500 Hertz. Graph **560** illustrates actual sound loss measurements through the specific materials tested. The insertion losses shown in FIG. **13** were generated using the ASTM Test Method No. WK5285.

Graph **560** includes a face shield insertion loss **562** corresponding to the material forming face shield **500** and a shell insertion loss **564** corresponding to the nonwoven laminate with a polyethylene film material that forms shell **410**. Graph **560** also shows an insert insertion loss **566** corresponding to the meltblown nonwoven material that forms inserts **450** and insert **460** and a background baseline insertion loss **568**.

Face shield **500** has a maximum insertion loss **562** of 25 dB over the tested frequency range. Shell **410** has a maximum insertion loss **564** of 12 dB over the tested frequency range. Ear sound transmission inserts **450** and mouth sound transmission insert **460** has a maximum insertion loss **566** of 6 dB over the tested frequency range.

The use of ear sound transmission inserts **450** and mouth sound transmission insert **460** causes an appreciable increase in the sound level transmitted through personal protection system **50** and hood **400**. Ear sound transmission inserts **450** appreciably improve the hearing of the wearer and mouth sound transmission insert **460** appreciably improves the comprehension of speech spoken by the wearer of hood **400**.

IV. Helmet with Ultraviolet Inspection Light

Referring to FIG. **15**, a personal protection system **600** is illustrated. Personal protection system **600** includes a helmet **100** that is worn on the head of a user and a hood **650** with an integrated face shield **700** that is draped over the helmet **100**. An ultraviolet inspection light assembly **800** is attached to the helmet **100** and located under the hood **650**. The personal protection system **600** creates a sterile barrier between the wearer and an external environment.

The personal protection system **600** is useful in many medical environments. System **600** is particularly adapted for use in a sterile processing department to protect technicians from contact with pathogens and medical waste during cleaning processes for medical/surgical instruments **610**. The ultraviolet inspection light assembly **800** is used during cleaning and inspection of medical/surgical instruments **610** to aid in the detection of adhered tissue **615** and body fluids are attached to the instruments **610**. Because tissue and body fluids fluoresce under applied ultraviolet light **620**, a tech-

nician using ultraviolet inspection light assembly **800** can readily detect the presence of adhered tissue and body fluids **615**.

Turning to FIGS. **16-18**, details of personal protection system **600** will now be described. The ultraviolet inspection light assembly **800** is mounted to the front of helmet **100**. Helmet **100** is the same as previously described in FIGS. **2-8**. Front nozzle assembly **160** further includes a pedestal **180** that is mounted between discharge nozzle **168** and head band **130**. Pedestal **180** supports and spaces discharge nozzle **168** from the head of the wearer.

Ultraviolet inspection light assembly **800** comprises a light angle adjustment mechanism **810**, a light housing **860**, ultraviolet light emitting diodes **870** and a shell **880**. Light angle adjustment mechanism **810** allows the user to change the direction of the beam of ultraviolet light **620** (FIG. **15**) so it can be directed to a specific location.

Light angle adjustment mechanism **810** includes a bracket **812**, a collar **822** and a control lever **840**. Bracket **812** has a base **813**. Two spaced apart parallel legs **814** are integrally formed with base **813** and extend perpendicularly away from base **813**. A slot **816** is defined between legs **814**. Holes **817** extend through base **813** and an aperture **818** is defined through the distal end of each of legs **814**.

The bracket **812** is attached to pedestal **180**. A base **813** is located adjacent to the lower side of pedestal **180**. Fasteners **820** such as rivets extend through holes **817** and are received by openings (not shown) in pedestals **180** to hold bracket **812** to pedestal **180**.

The collar **822** is circular in shape and has a center opening **823**, an upper bore **824**, a lower bore **825** and an angled bore **826**. The center opening **823** of collar **822** fits over the proximal end of light housing **860** and is tightened around the proximal end of light housing **860** by fastener **827**. Fastener **827** is a screw and nut. The screw extends through lower bore **825** and mates with the nut. The collar **822** is pivotally attached to legs **814**. The upper end of collar **822** is received in the slot **816** between the legs **814**. A shoulder bolt **828** extends through apertures **818** and upper bore **824** to pivotally retain collar **822** to bracket **812**. One end of the shoulder bolt **828** is threaded and receives a nut.

The control lever **840** is attached to collar **822**. The control lever **840** includes a triangular shaped handle **842**. The handle **842** allows the user to manipulate the control lever **840**. An arm **844** is connected to handle **842** and extends away from handle **842**. Arm **844** terminates in a foot **846** that contains a through hole **848**. A foot **846** is attached to the upper part of collar **822** by a fastener **850** that is received by angled bore **826**.

When the hood **650** (FIG. **15**) is placed over helmet **100**, the handle **842** extends above the face shield **700** (FIG. **15**) against an inside surface of shell **410**. In this position, the user's hand, from outside of shell **410**, can grasp and manipulate handle **842** through the shell to rotate collar **822** about the axis of pin **828**. The rotation of collar **822** changes the angle of light housing **860** and the direction of the beam of ultraviolet light **620** allowing the light to be directed to a desired location.

The light housing **860** has one end that is cylindrical and another end that is in the shape of a cut off cone. A circuit board **872** is mounted within light housing **860**. An ultraviolet light source, such as ultraviolet light emitting diodes (UVLEDS) **870**, are mounted to circuit board **872**. The UVLEDS **870** are mounted to circuit board **872** by suitable electronic assembly techniques such as soldering. Suitable ultraviolet light emitting diodes **870** are commercially avail-

able as model number LZ-100U600 from LED ENGIN Corporation having offices in San Jose, Calif.

Each ultraviolet light emitting diode **870** emits light in the ultraviolet frequency spectrum. Specifically, UVLED **870** emits ultraviolet (UV) light having wavelengths between 325 and 400 nanometers. The UV light in this frequency range causes tissue and body fluids to fluoresce. The fluorescence of these materials simplifies their visual detection.

In an optional embodiment, one or more of the UVLEDS **870** is replaced with a red visible light LED **871**. The red visible light LED **841** is readily visible to others in the vicinity of ultraviolet light assembly **800**. The red visible light LED **871** serves as a warning signal to other personnel and technicians that UVLEDS **870** are in operation.

An electrical cable **890** has one end **892** that is connected to circuit board **872** and another end that terminates in an electrical connector **894**. The connector **894** mates with another connector portion on primary PCB **302** (FIG. 6). Cable **890** is routed in a hidden manner along and within portions of support structure **128**. A cable clamp **896** retains a portion of cable **890** to support structure **128**. The cable **890** supplies electrical power to UV light source **870** from primary PCB **302**.

In one embodiment, a switch button **898** allows a user to selectively turn UVLEDS **870** on and off. Switch button **898** is mounted to the distal facing surface of chin bar **132** and connected to primary PCB **302**. A user can depress button **898**, through the material of shell **410** (FIG. 15), while wearing hood **650** (FIG. 15). In another embodiment, primary PCB **302** contains a timer circuit that turns off UVLEDS **870** after a pre-determined inspection time period.

In an additional embodiment, helmet **100** contains a Hall Effect sensor **899** that senses the presence of hood **650** when hood **650** is being worn. Hall Effect sensor **899** is mounted to the distal facing surface of chin bar **132** adjacent to lower mounting device **170**. In this example, lower mounting element **740** (FIG. 19) is a magnet and lower mounting device **170** is a material attracted to magnets such as steel. Hall Effect sensor **899** is connected to and in communication with primary PCB **302**. The primary PCB **302** includes a control circuit that only allows UVLEDS **870** to be turned on when a signal is received from Hall Effect sensor **899** indicating the attachment of the lower mounting element **740** and that hood **650** is being worn.

A slanted shell **880** encircles the outlet end of light housing **860**. A ring clamp **888** is mounted around the outer circumference of shell **880** and tightened around light housing **860**. A light passage **882** extends through the center of shell **880**. UV light from UVLEDS **870** passes through passage **882** and exits shell **880**.

When an individual puts on system **600**, the housing **860** that contains the LEDs is spaced inwardly from the hood face shield **700**. Shell **880** extends from the light housing to against the inner surface of face shield **700** (FIG. 15). The shell **880** prevents UV light rays **620** from being reflected off the face shield **700** back toward the user. Shell **880** also collimates the emitted UV light rays from UVLEDS **870** toward the desired target.

The ultraviolet inspection light assembly **800** is positioned directly under the air discharge nozzle **168**. By positioning as such, the air discharged from discharge nozzle **168** blows any warm air surrounding the light assembly **800** away from the light assembly. This reduces the amount of heated air adjacent the light assembly. Instead, the heated air is exhausted out of the hood **650**. The removal of this heated

air lessens the extent to which the heat generated by light assembly **800** warms the wearer of the personal protection system **600**.

With reference to FIGS. 19 and 20A-C, details of the hood **650** and face shield **700** are shown. Hood **650** is similar to hood **400**. For ease of illustration the inserts **450** and **460** are omitted.

The face shield **700** is flexible and transparent. As shown in FIG. 15, the face shield **700** is mounted to the distal facing front section **412** such that the face shield **700** covers the facial opening **134** of the helmet **100** after the individual dresses into system **600**.

The face shield **700** includes a multi-layered lens. Face shield **700** includes two lenses, an outer ultraviolet (UV) passing lens **710** and an inner UV blocking lens **750**. The passing lens **710** allows UV light to be transmitted or pass therethrough. In one embodiment, UV transmission lens **710** is molded or formed from a transparent plastic such as polycarbonate, acrylic or polyethylene terephthalate (PET). PET is also commonly called polyester. The passing lens **710** is generally rectangular in shape with rounded corners. Passing lens **710** includes a top portion **712**, a bottom portion **714**, an outer peripheral edge **716** and a sealing perimeter **718**. Lens **710** also has a distal facing outer surface **722** and a proximal facing interior surface **724**.

Blocking lens **750** prevents UV light from being transmitted therethrough. The blocking lens **750** is extruded and formed from transparent PET that contains UV light blocking additives. An example of one such UV blocking additive is Ultimate UV 390-1. Ultimate UV 390-1 is commercially available from Colormatrix Corporation of Cleveland, Ohio. Ultimate UV 390-1 is added and mixed with the PET material prior to extruding of UV blocking lens **750**.

The outer facing surface of blocking lens **750** is attached to the inner facing surface of the passing lens **710** by suitable methods such as adhesives, heat staking or ultrasonic welding.

Passing lens **710** is mounted over opening **440** slightly overlapping hood inside surface **424**. Lens **710** can be sealed to the shell **410** by the same means by which lens **500** is sealed to the shell.

An upper mounting element **730** is disposed on the passing lens **710** along the top portion **712**. The upper mounting element **730** is centered on lens **710** along the top portion **712**. The upper mounting element **730** is a rectangular shaped aperture **732** defined through the lens **710**. The upper mounting element **730** is configured for fastening to an upper mounting device **184** (FIG. 2) included on the helmet **100**.

Two lower mounting elements **740** are disposed on the UV transmission lens **710** along the bottom portion **714** of inner surface **724** and facing in a proximal direction. The lower mounting elements **730** may be the same components found on lens **500**.

The blocking lens **750** is generally rectangular in shape with rounded corners. Blocking lens **750** includes a top portion **752**, a bottom portion **754**, an outer peripheral edge **756** and a U-shaped opening or slot **760**. UV blocking lens **750** further has a distal facing outer surface **762** and a proximal facing interior surface **764**.

UV blocking lens **750** is slightly smaller in area than UV transmission lens **710**. The distal facing outer surface **762** of UV blocking lens **750** is attached to the proximal inner facing surface **724** of outer UV transmission lens **710** by suitable methods such as adhesives or heat staking. The combination of inner UV blocking lens **750** and outer UV

transmission lens **710** is transparent to visible light but, blocks UV light except through opening **760**.

During use, the hood **650** is placed over the head of the user and attached to helmet **100**. The upper mounting element **730** is fastened to upper mounting device **184** (FIG. 2) and the lower mounting elements **740** are attached to the corresponding lower mounting devices **170** (FIG. 2). The upper mounting element **730** centers the face shield **700** about UV inspection light assembly **800** (FIG. 15) such that shell **880** faces into U-shaped opening **760**. In this position, UV light rays **620** (FIG. 15) emitted by UV inspection light assembly **800** pass through opening **760** and the section **715** of lens **710** disposed in the opening toward the desired target.

Blocking lens **750** reduces, if not eliminates, the transmission of UV light that may be reflected off surfaces outside of system **600** and that could enter the hood **410** through face shield **710**. This reduces the likelihood that the UV light emitted by the system will reflect into the eyes of the individual. This results in a like reduction to which this reflection of ultra violet light could damage the eyes of the individual wearing the system.

The combination of outer UV transmission lens **710** and inner UV blocking lens **750** in face shield **700** advantageously allows a technician to inspect medical/surgical instruments **610** using UV light and at the same time be protected from the effects of any reflected UV light rays.

UV light is defined as having a wavelength of 100 to 400 nanometers. The preferred wavelengths for the inspection and detection of body tissue and fluids are in the range of 360 to 380 nanometers. In an optional embodiment, UV blocking lens **750** can be tinted with a coating or additive such that only UV wavelengths in the range of 360 to 380 nanometers are transmitted through UV blocking lens **750**.

FIG. 21 illustrates a graph **900** of percent light transmission versus wavelength for several different lens materials used in face shield **700**. Graph **900** compares the light transmission characteristics of several polyester (PET) based materials using different additives. The visible frequency range for the human eye is between 390 to 710 nanometers. Graph **900** illustrates the light transmission in percent (%) over the wavelength range of 300 to 440 nanometers. Graph **560** illustrates actual light transmission measurements through the specific lens materials tested.

Graph **900** includes line **902** that corresponds to the percent light transmission for the PET material that forms the UV transmission lens **710**. Line **904** corresponds to the percent light transmission for a PET lens containing the additive material identified as Ultimate UV370-1. Line **906** corresponds to the percent light transmission for a PET lens containing the additive material identified as Ultimate UV390-1 that forms the UV blocking lens **750**.

Graph **900** shows that in the UV frequency range of 320 to 400 nanometers, the UV transmission lens **710** formed using PET without any additives, has only a slight reduction in the UV light transmitted. In comparison, the UV blocking lens **750** formed using PET containing the Ultimate UV390-1 additive almost entirely blocks any photonic energy (UV light) from being transmitted through blocking lens **750**.

The above is directed to specific versions of the invention. The invention may have features different from what has been described.

For example not all features may be included in all versions of the invention. Thus, some versions of this invention may only include the described UV light/lights for rendering microorganisms innocuous. These versions of the

invention will not include the shell with inserts that, in comparison to the surrounding fabric, only minimally distorts the transmission of sonic energy. Likewise the versions of the invention with the inserts designed to reduce the distortion of sonic energy may not be used with the versions of the invention that include components for emitting light in order to render microorganisms.

Further versions of the invention with inserts designed to minimize the distortion of the sonic energy through the shell may be located around only one of the mouth or ears.

Versions of the invention with lights that emit photonic energy used to inspect products may need not always be incorporated into other versions of the invention.

The arrangements of the components that form the inventions of this application may differ from what has been described. For example, in some versions of the invention the lights that emit photonic energy to render microorganism innocuous may be located in the one or more outlet ducts. Alternatively, these lights may be located both in the inlet duct and the one or more outlet ducts.

Similarly, the features of this invention may be incorporated into personal protection systems that have features different from what has been described. Thus not all personal protection systems of this invention have ducts capable of discharging air both in front of and behind the persons wearing the system.

Likewise, not all personal protection systems of this invention include helmets worn on the head. A personal protection system of this invention may include a fixed unit that is supported by the shoulders of the wearer. This fixed unit includes structural components that hold the hood above the head of the wearer and the ventilation unit that draws air into the hood.

The fastening members used to hold the hood to the support structure that holds the hood above the head of the individual wearing the system are likewise understood to be exemplary and not limiting. In alternative versions of the invention snaps, hook-and-loop fasteners and adhesives can be used as the components that hold the hood to the support structure.

The structure of the hood face shield that blocks the reflection of light back into the hood may also vary from what is described. In an alternative version of the invention, the section of the face shield that allows the transmission of the UV light through the face shield may be an insert into a larger component. This larger component is formed from material that blocks the transmission of the UV light. This larger component is formed with an opening to which the insert that is transparent to UV light is seated.

It should likewise be understood that the features of the various versions of the personal protection system of this invention can be combined as necessary.

Therefore, it is an object of the appended claims to cover all such variations and modifications that come within the true spirit and scope of this invention.

What is claimed is:

1. A personal protection system for use during a surgical procedure, said system comprising:
 - a helmet configured to be worn on a head of a user wearing said system, said helmet comprising:
 - a ventilation assembly;
 - a chin bar comprising a mounting device;
 - a hall effect sensor mounted to said chin bar adjacent said mounting device; and
 - a control circuit in communication with said hall effect sensor;

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a hood at least partially disposed over said helmet, said hood comprising:

a flexible shell defining an opening;

a transparent face shield disposed within said opening and attached to said shell; and

a mounting element configured to removably couple with said mounting device of said helmet when said hood is at least partially disposed over said helmet;

wherein said control circuit is configured to receive a signal from said hall effect sensor indicating the coupling of said mounting element of said hood with said mounting device of said helmet.

2. The personal protection system of claim 1, further comprising a light assembly coupled to said helmet, said light assembly configured to emit a beam of light within a range of wavelengths that cause biological tissue and fluid to fluoresce and be visible to the user.

3. The personal protection system of claim 2, wherein said light assembly is configured to emit said beam of light at said range of wavelengths is defined to be a wavelength between 325 and 400 nanometers.

4. The personal protection system of claim 3, wherein said light assembly is configured to emit said beam of light at said range of wavelengths is defined to be a wavelength between 360 to 380 nanometers.

5. The personal protection system of claim 2, wherein said light assembly further comprises an adjustment mechanism configured to allow the user to adjust the direction of said beam of light emitted by said light assembly.

6. The personal protection system of claim 5, wherein said adjustment mechanism further comprises a handle, said handle configured to extend above said transparent face shield when said hood is at least partially disposed over said helmet to allow the user to grasp said handle to manipulate the direction of the beam of light emitted from said light assembly from outside said flexible shell.

7. The personal protection system of claim 2, wherein said light assembly comprises a plurality of LED lights, at least one of said plurality of LED lights is an ultraviolet LED light.

8. The personal protection system of claim 7, wherein at least one of said plurality of LED lights is a red LED light that is visible to individuals in the vicinity of the light assembly to serve as a warning that said ultraviolet LED light is in use.

9. The personal protection system of claim 2, wherein said transparent face shield further comprising:

a first lens comprising a distal surface and an opposing proximal surface, said first lens formed from material configured to allow the transmission of ultraviolet light within said range of wavelengths therethrough said first lens; and

a second lens disposed on said proximal surface of said first lens and formed from a material configured to prevent ultraviolet light from being transmitted through said second lens to reduce the likelihood that ultraviolet light emitted by said light assembly will reflect into the eyes of the user.

10. The personal protection system of claim 9, wherein said second lens comprises an opening configured to be aligned with said light assembly when said hood at least

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partially disposed over said helmet to allow the beam of light emitted from said light assembly to pass through said first lens.

11. The personal protection system of claim 9, wherein said second lens comprises a coating or additive that prevent ultraviolet light comprising a wavelength in the range of 360 to 380 nanometers from passing through said second lens.

12. The personal protection system of claim 2, wherein said control circuit is configured to only allow said light assembly to be turned on when said signal is received from said hall effect sensor indicating the attachment of said mounting element with said mounting device.

13. The personal protection system of claim 2, wherein said hall effect sensor is mounted to a distal facing surface of said chin bar.

14. The personal protection system of claim 2, wherein said ventilation assembly comprises:

a lower shell;

an upper shell attached to said lower shell;

an intake cover mounted to said upper shell; and

a fan disposed between said upper shell and said lower shell and is configured to draw air in through said intake cover.

15. A helmet for use with a hood during a surgical procedure, the hood including a mounting element configured to removably couple with the hood to said helmet, said helmet comprising:

a ventilation assembly;

a chin bar comprising a mounting device configured for removable attachment with the mounting element of the hood;

a hall effect sensor mounted to said chin bar adjacent said mounting device; and

a control circuit in communication with said hall effect sensor;

wherein said control circuit is receives a signal from said hall effect sensor indicating the attachment of the mounting element with said mounting device.

16. The surgical helmet of claim 15, further comprising a light assembly coupled to said helmet, said light assembly configured to emit a beam of light within a range of wavelengths that cause biological tissue and fluid to fluoresce and be visible to the user.

17. The surgical helmet of claim 16, wherein said control circuit is configured to only allow said light assembly to be turned on when said signal is received from said hall effect sensor indicating the attachment of the mounting element with said mounting device.

18. The surgical helmet of claim 16, wherein said light assembly is configured to emit said beam of light within said range of wavelengths is defined to be a wavelength between 325 and 400 nanometers.

19. The surgical helmet of claim 16, wherein said light assembly comprises a plurality of LED lights, at least one of said plurality of LED lights is an ultraviolet LED light.

20. The surgical helmet of claim 19, wherein at least one of said plurality of LED lights is a red LED light that is visible to individuals in the vicinity of the light assembly to serve as a warning that said ultraviolet LED light is in use.

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